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ABSTRACT

The first of a two-volume report on motor vehicle driving by handicapped persons focuses on driving behavior for 19 types of handicapping conditions. Information is detailed regarding driver education and assessment materials, present state laws regarding licensing, relevant medical opinion regarding licensing and examination, complicating factors (such as the use of therapeutic drugs), and private and commercial driving behavior for specific conditions, including the following: mental retardation, mental illness, neurologic and cerebrovascular handicaps, epilepsy, diabetes, musculoskeletal handicaps, hearing disorders, thyroid disease, renal disorders, cancer, and obesity. Automotive adaptive equipment is briefly considered. Among 12 recommendations made are for a more comprehensive analysis of the driving task for normal drivers, a large scale epidemiological study to measure the accident and violation rates of specific handicapped groups, and validated assessment and evaluation procedures. (CL)

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IMPACT STUDY ON DRIVING BY SPECIAL POPULATIONS

Volume I - Conduct of the Project and State-of-the-Art

Contract No. DOT-HS-5-01206
April 1977
Final Report

PREPARED FOR:

U.S. DEPARTMENT OF TRANSPORTATION
NATIONAL HIGHWAY TRAFFIC SAFETY ADMINISTRATION
WASHINGTON, D.C. 20590

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16. Abstract

This project was conceived to study the impact of motor vehicle driving on the public roadways by "special populations." Major concerns were special populations' learning to drive, being licensed to drive, and driving behavior. Impact was considered from two perspectives: the impact on the handicapped driver and the impact on the welfare of the general public.

The project was divided into two phases. Phase I established a research data base of information directly relevant to special population motor vehicle driving. This information is summarized and presented in Volume I of the Final Report: Impact Study on Driving by Special Populations (Conduct of the Project and State of the Art). Volume II - Impact Study on Driving by Special Populations (A Guide for the Evaluation of Handicapped Drivers) draws upon information collected during Phase I and synthesizes these data into immediately usable products which will improve the circumstances under which special populations drive. The second volume presents an approach to the evaluation of the license applicant who is handicapped which is useful not only for licensing officials but also for driver education and other professionals involved in the rehabilitation of handicapped persons.

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METRIC CONVERSION FACTORS

Approximate Conversions to Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
in	inches	*2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
		AREA		
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
		MASS (weight)		
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
		VOLUME		
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
		TEMPERATURE (exact)		
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

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*1 in = 2.54 (exactly). For other exact conversions and more detailed tables, see NBS Misc. Publ. 286, Units of Weights and Measures, Price $2.25, SD Catalog No. C13.10:286.

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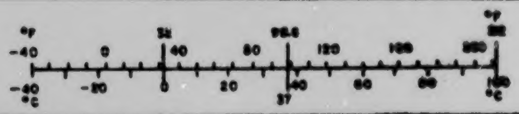
Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
		AREA		
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
		MASS (weight)		
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
		VOLUME		
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
		TEMPERATURE (exact)		
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



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This project was conceived to study the impact of motor vehicle driving on the public roadways by "special populations." The major concerns were special populations learning to drive, being licensed to drive, and driving behavior. Impact was considered from two perspectives: the impact on the handicapped driver and the impact on the welfare of the non-handicapped public. The impact on the handicapped focused on personal safety and mobility issues. The impact on the non-handicapped public focused on general public safety and on the benefits to a society with a mobile handicapped population.

The derivation of these perspectives can be found in the goals of the two agencies sponsoring the project. The National Highway Traffic Safety Administration of the U.S. Department of Transportation has the charter for saving lives on the country's roadways. This includes the safety of special population drivers themselves as well as the safety of other drivers, passengers, and pedestrians. The Bureau of Education for the Handicapped of the U.S. Department of Health, Education and Welfare has a responsibility for the training of handicapped persons, including driver training, to ensure the opportunity for lives and careers that are fruitful and worthwhile to themselves and to society.

The project was divided into two phases. The purpose of Phase I was to establish a data base of all directly relevant information. During Phase II, this information was utilized to develop products which are immediately useable and which improve the circumstances under which special populations drive. The two products produced by the project are distinctly different and constituted Volumes I and II of the Final Report. The first volume describes the wealth of information gathered in Phase I as well as the purpose and conduct of the total study. The second volume presents an approach to the evaluation of a license applicant or perspective applicant who is handicapped. This document, however, contains information useful not only to license officials but also to driver education and other professionals involved in the rehabilitation of handicapped drivers.

"PREPARED FOR THE DEPARTMENT OF TRANSPORTATION, NATIONAL HIGHWAY TRAFFIC SAFETY ADMINISTRATION UNDER CONTRACT NO.: DOT-HS-5-01206. THE OPINIONS, FINDINGS, AND CONCLUSIONS EXPRESSED IN THIS PUBLICATION ARE THOSE OF THE AUTHORS AND NOT NECESSARILY THOSE OF THE NATIONAL HIGHWAY TRAFFIC SAFETY ADMINISTRATION."

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FOREWORD

The National Highway Traffic Safety Administration (NHTSA) and the Bureau of Education for the Handicapped (BEH) sponsored the study on the impact of driving by special populations. The term "special populations" was broadly defined to include those people who have physical or mental handicaps which could affect their vehicle driving capabilities. The concern of both NHTSA and BEH was to study the complex issues of special populations' driving with the ultimate objectives of increasing public safety on the nation's highways and of increasing the mobility of all citizens. This present project addressed these complex issues and provided detailed information in advancing the state-of-the-art of knowledge in this field. This knowledge can be directly applied to the improvement of driver education and licensing of special populations.

Two official documents were produced as a result of the "Impact Study on Driving by Special Populations." Both of the documents are volumes of the Final Report. Volume I is a description of the project and a compilation of current thought on special populations' driving. The current information includes driver education, driver assessment, driving performance, and driver licensing. Volume II is a guide for the evaluation of handicapped individuals who are planning to drive.

Direction and guidance for the project was provided by Dr. Harold Booher, Contract Technical Manager, of the National Highway Traffic Safety Administration, and Dr. Max Mueller and Mr. Melville Appell of the Bureau of Education for the Handicapped. Thoughtful suggestions and comments were contributed throughout the project by Drs. John Eberhard, Jerry Tannahill, Michael Perel, Les Moore, and George McDonald of NHTSA. Discussions with Dr. Edward Pizer, Mr. Anthony Staros, Dr. Frank Schaffer, and Dr. William Holzberg of the Veterans Administration were also helpful.

The project was directed at Dunlap and Associates, Inc., of Darien, Connecticut, by Mr. Paul Brainin. Mr. Thomas Naughton and Mr. Robert Breedlove, members of the project staff, contributed greatly to the program's accomplishments. Mr. Joseph Fucigna, Executive Vice President, served as responsible corporate officer.

Dunlap and Associates, Inc., is especially indebted to the consultants to the project: Ms. E'lise Brown (aided by Ms. Mary Barber), Mr. Jiri Sipajlo, Mr. Joseph Reynolds, and Mr. Frank Gentile and Dr. Gerald Manus of Human Resources Center. We are also indebted to Marshall Franklin, M.D., for his assistance.

We are also grateful to all those individuals and organizations, too numerous to mention, who supplied us with valuable information. This information was assimilated and used as a resource for both volumes of the Final Report.

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APPENDIX A 139

I. INTRODUCTION

A. Background

This project was conceived to study the impact of motor vehicle driving on the public roadways by "special populations." The major concerns were special populations learning to drive, being licensed to drive, and driving behavior. Impact was considered from two perspectives: the impact on the handicapped driver and the impact on the welfare of the non-handicapped public. The impact on the handicapped focused on personal safety and mobility issues. The impact on the non-handicapped public focused on general public safety and on the benefits to a society with a mobile handicapped population.

The derivation of these perspectives can be found in the goals of the two agencies sponsoring the project. The National Highway Traffic Safety Administration (NHTSA) of the U.S. Department of Transportation has the charter for saving lives on the country's roadways. This includes the safety of special population drivers themselves as well as the safety of other drivers, passengers, and pedestrians. The Bureau of Education (BEH) for the Handicapped of the U.S. Department of Health, Education and Welfare has a responsibility for the training of handicapped persons, including driver training, to ensure the opportunity for lives and careers that are fruitful and worthwhile to themselves and to society. Other agencies, such as the Veterans Administration, although not an active sponsor of this contract, are potential benefactors of the results. The Veterans Administration is actively involved and concerned with driver education, licensing, and the safe driving of disabled veterans.

Driving in our society is as important, or more important, to handicapped persons as it is to other segments of our population. Personal use of an automobile is often a determinant factor both in employment and in the satisfaction of the basic human needs, from food acquisition to the psychological and social requirements of everyday life. A person unable to drive in our mobile society may lose the opportunity for personal freedom and independence. For those who become disabled after once having learned to drive, re-learning may be a significant part of their rehabilitation.

With access to an automobile, a handicapped individual who is unemployed may be able to obtain employment. The Abt study (1969) reported, that at the time of their report, only 36% of the national handicapped population aged 17 to 64 were members of the labor force. This compared to 71% employment of the non-handicapped population of the same age group. Not being able to drive is one of the many obstacles facing a handicapped person who wants employment.

In general, the less dependent on society the handicapped are, the more they are able to contribute to the welfare of their country. Certainly this contribution has a significant economic component. Instead of a cost to society, they become an asset.

The extent of the economic impact is partially determined by the number of people who are handicapped. In 1970, the President's Task Force on the Physically Handicapped reported that precise information about the numbers, location, and categories of the physically handicapped is not available. The Task Force estimated that, as of 1970, over 25 million persons were handicapped. At least 20 million persons were judged to require some assistance with approximately 14 million persons thought to be suffering from some major limitation.

There are also costs associated with driving and driver education. Driver education, for instance, requires allocation of resources, often from the general public. The primary cost of driving, however, is related to safety. This is the societal cost from the loss of human lives, human injury, and property damage. Therefore, in the determination of who should drive, one must consider the general welfare of other people on the road as well as the rights and needs of the individual driver. Since the impact study results contained in the two volumes of the Final Report discusses the driving of a significant number of individuals, the report has a potential effect, directly or indirectly, on most people in this country.

The project was divided into two phases. The purpose of Phase I was to establish a data base of all directly relevant information. During Phase II, this information was utilized to develop products which are immediately useable and which improve the circumstances under which special populations drive. The two products produced by the project are distinctly different and constituted Volumes I and II of the Final Report. The first volume describes the wealth of information gathered in Phase I as well as the purpose and conduct of the total study. The second volume presents an approach to the evaluation of a license applicant or perspective applicant who is handicapped. This document, however, contains information useful not only to license officials but also to driver education and other professionals involved in the rehabilitation of handicapped drivers. Further discussions of the end products of the program and conduct of the projects can be found in Section II below.

B. Definition of "Special Population" Terminology

Terminology varies considerably among the various disciplines concerned with "special populations" and even varies from study to study within a discipline.

Throughout this Final Report, the special populations term "handicapped," will be used in the sense in which it is defined below.

The contract for the present study stated: "The definition of the handicapped individual is broadly defined by the Office for the Handicapped (OFH) as one who has a physical or mental impairment or condition which places him at a disadvantage in a major life activity such as ambulation, communication, self-care, socialization, vocational training, employment, transportation, adapting to housing. The physical or mental impairment or condition must be static, of long duration, or slowly progressive."

It is useful to make the distinction between condition, impairment, functional limitation, disability, and handicap. A condition is a description of a departure from a state of physical or mental well-being (U.S.D.H.E.W., 1974). The condition (or disease and injury) residuals are referred to as impairments, relating primarily to abnormalities in physical and mental structure and functioning. The activity losses or restrictions resulting from impairments are referred to as functional limitations. A disability is a functional limitation in a major life activity. The term "handicap" is used in referring to defects and limitations imposed by disease or injury, as well as to social disadvantage. Handicaps are frequently referred to as limitations an individual has or has not overcome. In this sense, handicaps may be considered as competitive disadvantages. The individual may retain or develop the ability to cope with the environment by minimizing the extent of incapacity or, more affirmatively, by optimizing the use of his residual capacities. Handicaps presuppose the existence of an impairment of structure or function but not necessarily of a functional limitation or disability (Haber, 1967).

C. General Limitations of the Study

Ground rules were established at the initiation of the project in the Preliminary Work Plan and subsequent revision to the Plan as well as in meetings with NHTSA and BEH. These rules created boundaries to the scope of the subject matter of interest in the project. The boundaries allowed the concentration of the project resources on the handicapped groups of most interest. Those groups, deleted from concern in the project, were dropped primarily because they were and are subject of specific study in other programs. It was thought unnecessary to duplicate these other programs. These groups are:

- The elderly--There are persons considered as a group solely as a consequence of their advanced age. However, most of the impairments that these people suffer from are covered in this report.

- Drug abusers -- This includes all use of alcohol and other essentially non-therapeutic drugs as well as over-use of therapeutic drugs. This paper does report, in a limited sense, on the effects of therapeutic drugs.

- School dropouts--These people who, because of their dropping-out of school, are considered disadvantaged. However, people who have physical or mental impairments (e.g., mental deficiency) and then drop out of school are of interest not because they have dropped out of school but because of their impairment.

- Visually impaired--These are persons who have a variety of vision impairments. Vision, in the current study, is only considered when it is a manifestation of a medical condition which causes other impairments in addition to visual ones.

Not only were boundaries established which affected the selection of handicapped groups for study, but also boundaries were formed concerning the relevance of the studies which were reviewed. There are many disciplines or areas of research that impinge upon the consideration of driving and handicapped persons. There are the general areas of traffic safety, education, medicine, psychology (particularly studies of psycho-motor capabilities of impaired persons), physiology, etc. Studies in these areas may discuss driving or education but not handicapped driving or education, and they may talk about handicaps but not relate them to driving or driver education. No attempt was made to review all of these studies. The studies of most interest were those which considered the combination of both driving (in any aspect) and the handicapped. The emphasis in the review of the literature was upon the specific studies of handicapped driving behavior, driver licensing of the handicapped, and driver education of the handicapped. However, the studies reported in the Final Report come from these many disciplines (and others) and reflect their perspectives. In addition, many studies of a general nature were seen, but usually not referenced.

II. CONDUCT OF THE PROJECT

This section describes, briefly, the conduct of the project through the two phases, culminating in Volumes I and II of the Final Report. The highest priority throughout the conduct of the project was to provide documented products which would have the greatest influence within the contract's limitations, in creating an optimum driving environment for special populations. From the perspectives of NHTSA and BEH, the optimum driving environment is one which would allow all capable handicapped drivers to drive safely. As a result of the priority and prevailing viewpoint, the work of the project was concentrated in establishing the state-of-the-art of special populations' driving in Phase I (and contained in Volume I) and in developing A Guide for the Evaluation of Handicapped Driver in Phase II (and contained in Volume II).

The project officially began with the contract award in 1975 and acceptance shortly thereafter of the "Preliminary Project Plan." A meeting was then held at NHTSA with the major Dunlap and Associates, Inc., project staff, NHTSA's Contract Technical Monitor and other intested NHTSA personnel and a representative from BEH to discuss the "Preliminary Project Plan." Following the meeting, the "Revision to the Project Plan" was submitted and accepted. Work then began on the major focus of Phase I, a review of the literature and expert opinion.

The project staff collected the following types of information in Phase I:

- Experimental and controlled research related to driving behavior and performance of the handicapped--there was not much of this information available. Most that was available suffered from poor design and execution. This made it difficult to integrate the information since the data was often contradictory.

- Experimental and controlled research related to driver education and licensing of the handicapped--there was less of this information available than the data mentioned above, and the difficulty with its interpretation was similar.

- Case history and expert opinion related to driving behavior and performance of the handicapped--there was quite a large quanity of this information available. However, it was, by its nature, subjective, and subjective data is difficult to interpret.

- Licensing and education standards, regulations, rules and guidelines related to driving for the handicapped--this information was collected from the U.S. and from several foreign countries.

- Statistical data related to the handicapped--some statistical data was collected. Unfortunately, more statistics that were available were incomplete and inconsistent. A typical problem was in the definition of a handicapped. Data from different sources concerning a handicap may vary by several magnitudes depending upon the definition and assumption made.

- Driver educational materials for the handicapped--this included lesson plans, instructor guides, student manuals, workbooks, supportive course information, and instructional aids. Very little of this has been published. Most that was available at all was loaned to the project. In most cases only descriptions of programs were available.

- Assessment devices related to driver education and licensing of the handicapped--some information was available. These devices have been used for evaluating and screening people for education programs, for evaluating during education programs, for evaluating successful completion of educational programs, or for screening for licensing. Few of the devices have been validated for their purported use.

Four approaches were used to collect information on the state-of-the-art of handicapped driving. These were: (1) acquiring opinions as well as the published and unpublished materials from the project consultants (all experts in their fields), (2) acquiring the opinions and materials from other experts and officials, (3) running computer literature searches and acquiring appropriate documentation, and (4) seeking other references to relevant documents and acquiring these materials.

Invaluable assistance was rendered the project staff by the project consultants. Drawing upon their own expertise and knowledge, they contributed useful opinions and recommendations. They also assisted members of the project in assessing and interpreting the materials collected. In many instances they were helpful in locating and securing copies of studies (both published and unpublished) from personal libraries that would otherwise have been unavailable. The consultants also provided leads to other experts in the subject matter under investigation.

Hundreds of people, prominent in the area of the handicapped, driver licensing, driver education, and driver behavior were contacted by the project staff.

Their opinions, research studies, relevant data, curricula, etc., were solicted. The following represents the types of organization that were contacted:

- Associations for the handicapped and other professional associations concerned with the handicapped
- Universities
- Research firms
- Institutions and schools (public and private)
- Prominent individuals in related fields not associated with any of the above or no longer involved in related work

Computer searches were used to scan journal articles, books and dissertations to identify relevant information for the project. It was possible to search literally millions of individual reports to find those suitable. The following computer searches were performed:

- ERIC--This is an abstracting index that primarily covers the fields of education, educational psychology, and psychology.
- Psychological Abstracts--These cover the fields of psychology, sociology and related areas.
- Highway Safety Literature Data Base--This data base contains the literature concerning the highway traffic safety field and is multidisciplined.
- MEDLINE and BACKFILE--These contain three abstract indexes from the medical field: Index Medicus, International Nursing Index, and Index to Dental Literature.
- CEC--This is the Center for Exceptional Children Index, a multi-disciplined index.
- NTIS--The National Technical Information Service contains an index of government reports.
- SSIE--This is the Smithsonian Scientific Information Exchange which contains information on both government and private industrial contracts and grants in progress or very recently completed.

Once having obtained these basic citations the project staff then acquired the actual referenced documents from libraries, institutions and personal files. This material, in turn, led to other references and citations which were similarly collected. As a crosscheck on the literature thus accumulated and to assure completeness, the Science Citation Index was also accessed. Very few relevant new articles were found, attesting to the thoroughness of the original search.

Emphasis was placed on research information for the period beginning in 1960 and continuing through 1976, although prominent articles before 1960 were reviewed. The information was collected from many countries: the United States, Canada, West Germany, Great Britain, Israel, Switzerland, East Germany, Russia, Sweden, Denmark, France, Finland, Australia, and others. Those articles not available in English were translated. The sum of this effort was an exhaustive collection of information concerning the impact of special populations on driving.

In order to present this information in an orderly fashion in the Final Report, the handicaps had to be organized into meaningful groupings. The objective was to classify the handicaps in a methodical manner. To accomplish this, a number of disease classification schemes, disability surveys and guides were collected and reviewed during Phase I. A representative number are listed below.

- American Medical Association. Physicians guide for determining driver limitation. Chicago: American Medical Association, 1973.
- American Psychiatric Association, Diagnostic and Statistical Manual of Mental Disorders, 1968.
- Canadian Medical Association, Committee on Emergency Services. Guide for physicians in determining fitness to drive a motor vehicle. Ottawa: Canadian Medical Association, 1974.
- Haber, L. The epidemiology of disability: II--The measurement of functional capacity limitations. Social Security survey of the disabled, 1966. Report No. 10, July 1970.
- Kay, H.W., & Newman, J.D. Amputee survey, 1973-74: Preliminary findings and comparisons. Orthotics and Prosthetics, 1974, 28 (2), 33-48.
- Nova Scotia Medical Society, The Committee on Traffic Accidents. Nova Scotia guide for physicians in determining fitness to drive a motor vehicle. The Nova Scotia Medical Bulletin, May 1966, 3-12.

- Quebec Ministry of Transport. Medical guide to determine ability to drive a motor vehicle. Department of Transport, July 1973.

- U.S. Bureau of the Census. Census of population: 1970, subject reports final report PC(2)-6C, persons with work disability, 1973.

- USDHEW, Office of Human Development, Rehabilitation Services Administration. Statistical reporting system, coding of disabling conditions. Rehabilitation Services Manual, July 1974.

- USDHEW, Public Health Service. Eighth revision, international classification of diseases, adapted for use in the United States: Volume I, Tabular list, 1967.

- USDHEW, Public Health Service, Health Resources Administration Current estimates from the health interview survey: United States-1973, 1974.

Many authors have stated that up to now there has been a great deal of conceptual confusion in the terms used to identify and classify disabilities (Haber, 1975; Nagi, 1975). Even a cursory review reveals large inconsistencies in the use of the terms illness, handicap, disability and impairment. As Slater (1974) has pointed out, working definitions of disability must vary to accommodate the subjective legal, economic, medical, and social purposes. For instance, in hospital record keeping in this country, the International Classification of Diseases (accepted as a standard of classification for mortality statistics) had to be adapted in order to maintain statistics on morbidity. The USDHEW, Social Security Administration collects "disability" data on the incidence of work-impairing disabilities which specifically impacts on its payment of social security insurance. The National Center for Health Statistics (National Health Surveys) collects "disability" information by its definition on pathology and impairment but then only for certain populations. A specific handicap has many dimensions (e.g., anatomical region of disease process). The principal dimension chosen as an axis of classification is dependent upon the intended use of the data.

A classification scheme has to be understandable to the people who will use it. The major receipents of the Final Report will be highway safety, licensing and education personnel. There are five general types of persons who will be major users of a classification scheme for licensing the handicapped. They are the licensing lawmakers, license examiners, medical advisory boards, physicians, and the handicapped themselves. These people need to be able to classify individuals (or themselves) to develop and interpret licensing regulations. Curriculum

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designers, special education teachers, driver education instructors, and the handicapped themselves, will be major users of a classification scheme utilized in education. They need to be able to classify and understand handicapped people to be able to develop and teach driver education to them.

The feasibility of classifying handicaps according to relevant functional limitations or functional capabilities was considered. The most relevant functional limitations or capabilities could be to relate to behavior during driving. However, to relate this to driving behavior specifically was impossible. This would require detailed information of the driving task--the perceptual, cognitive and motor components of driving. This information does not exist in much detail for the able-bodied or the handicapped driver (see Section IV of this report for a detailed description of the driving task). Even if this form of classifying handicaps were feasible, it could be troublesome to the potential user of the information, education and licensing personnel, who are using other classifications. Currently, a medical condition classification scheme is most prevelant.

A medical condition classification system describes disabilities from a disease perspective, e.g., cardiovascular disease, epilepsy, diabetes, etc. Not only is this approach currently being used by licensing and education persons, but it is generally how relevant research is described. In order to integrate the information collected in the project meaningfully and to facilitate its application, the classification scheme that has been applied in Volume I and II of the Final Report is of the medical condition variety.

Once a classification scheme was established, the information gathered in Phase I was presented in a preliminary form in the "Interim Report." The contents of the Interim Report was the subject of a meeting which was attended by members of the Dunlap and Associates, Inc. project staff and representatives of NHTSA, BEH, VA and other organizations. It was decided that since the Interim Report was not an official project document (only a working paper) and since it was in a preliminary form that a finalized complete version would be produced in Phase II of the project and appear in the Final Report. The description of the data collected in Phase I can be found in Section IV of this report (Volume I of the Final Report). This section presents the information but does not draw firm conclusions from it. In a sense, the conclusions can be found in Volume II (a Guide for the Evaluation of Handicapped Drivers). Volume II was derived from the interpretation of the information collected in Phase I. It is expected that the readers of Volume I will have many different reasons for seeking the information contained herein--from medical research to driver education to licensing handicapped drivers. Each will interpret the data for his own interests and needs, and each certainly, will want to collect more details from the original studies. All studies are fully referenced in Section VI of Volume I.

At the completion of Phase I, there was an opportunity to select target groups for further study in Phase II and to plan the best allocation of remaining resources for completion of the project. The process of defining the state-of-the-art during the first phase provided the data base for making these decisions for the second phase. At this point in the project, much more astute and sensible decisions could be made than were the preliminary judgments in the initial Work Plan.

Although a feasibility (cost)/benefit discussion contained in the Interim Report suggested the selection of all or part of six specific handicapped groups for additional work in Phase II, it was decided that a more general final project product would be the most beneficial. (The feasibility/benefits discussion was based upon prevelance statistics, data on driver performance, data on driver education, information on licensing and other relevant factors.) The general final products were to treat, and they have, all handicapped conditions covered in the Interim Report. Many target groups, then, were choosen rather than a selected few as it was initially conceived.

The completion of the major end-products of the program were the subject of Phase II. These products are contained in the two volumes of the Final Report, although some of the following products were begun in Phase I, they were not completed until Phase II. These products are (not necessarily in this order or addressed separately as distinct sub-sections in the Final Report):

- An analysis of data on driver education and licensing
- An analysis of data on handicapped drivers
- An analysis of driver educational techniques and materials
- An analysis of driver assessment instrumentation and methodology
- A model driver licensing and education system
- Specific identification and evaluation of assessment devices
- Identification of special target groups
- Identification of driver functional operational deficiencies
- Identification of special equipment

- Recommended driver license standards
- Guidelines for administering driver licensing examinations
- Identification of further research and development
- Description of purpose and conduct of the program

All Phase II activities were completed over several months with an emphasis on Volume II of the Final Report. (Much of Volume I was completed in draft form in Phase I.) Phase II activities were conducted by Dunlap and Associates, Inc. project staff, project consultants and with assistance by various other experts in the field. The reader is directed to the introduction in Volume II for a detailed description of that document and its use.

III. A DRIVER EDUCATION AND LICENSING SYSTEM MODEL

This section describes, in general, a driver education and licensing system for the handicapped motor vehicle operator. This system, as proposed, outlines the processes a person who has a medical problem should encounter in obtaining legal authority to operate a private motor vehicle on public highways. To a certain extent it is an idealized system, yet it was designed to be practicable. It is practicable in the sense that it requires no new technology for implementation, and most portions of the system already exist in the States; although the system as a whole does not.

This model is presented as a suggested system for licensing and education officials. This system will allow them to utilize the information contained in Volume I and, particularly, Volume II of the Final Report. It helps put into context the appropriateness of the data in this report. The system, itself, is intended to allow for the fair and equitable processing of potential special population drivers and to not restrict their personal mobility unnecessarily. On the other hand, it emphasizes considerations of safety for both the general public and the handicapped.

In the current legal and social milieu, the right to mobility makes this system model timely. Over the past few years the goals of driver licensing have been reexamined. The re-examination has become more critical recently following court decisions holding that access to a driver's license is more a right than a privilege. As greater numbers of the population grow older, as automotive technology advances, and as special interest groups assert the rights of their constituents, there will be increased pressure on licensing administration and driver education to modify existing licensing procedures and education programs to insure personal mobility.

Present state licensing administrations obtain their public safety charter through a set of statutes which are usually very general in nature. Essentially, these statutes prevent the issuance of a driver's license or renewal of a license when:

- A person who is suffering from a mental disability or disease is not restored to competency at the time of application.
- A person who has a physical or mental disability is not able to operate a motor vehicle safely.
- A person is a habitual user of a drug (including therapeutic drugs) which renders him incapable of safe driving.

Motor vehicle administrations, in most states, are empowered and directed by law to develop and implement licensing procedures to support the general statutes described above. In addition, these procedures need to treat individual driver applicants in, at least, a consistent manner so that the license decisions may be upheld in the courts when they are challenged. There is another pattern of legal reasoning emerging which further complicates the situation. If a driver's license is issued in a routine manner to a physically or mentally impaired person, without due regard for the potential driving hazards, the motor vehicle administrator may be held liable for damages or injury caused by this person. The administrator will probably not be held liable if there was evidence that reasonable administrative discretion was exercised. Any driver licensing system, therefore, should treat handicapped drivers in a consistent, fair, and reasonable manner so the licensing decisions may be upheld in the courts.

Perhaps the most straightforward method in treating handicapped drivers consistently, fairly and reasonably would be the application of specific medical fitness criteria related to driving. Unfortuantely, at the present state-of-the-art of information, it is impossible to be that specific about the criteria. In fact, Volume II of the Final Report, A Guide for the Evaluation of Handicapped Drivers, has significantly more detail than any guides produced previously. This, however, does not release the state licensing administrator from the task of developing and promulgating license regulations. As a consequence, Medical Advisory Boards (MAB) have been given the jobs of collecting information for developing criteria, of providing guidance to licensing personnel, and of applying expert technical judgement to more complex individual cases. The needed flexibility in individual judgements of a handicapped driver's capabilities by MAB's has been usually accepted legally, since most of the specific medical fitness criteria have been unavailable.

The judicial and legislative effect upon special populations' driver education has been oritented mostly to the younger driver. This has primarily taken the form of requiring equitable public education for handicapped children. Driver education has also been available to veterans, who are in need, through the Veterans Administration as part of some rehabilitation programs. Other driver education programs have been available through private and charitable institutions for primarily the mentally retarded, the hearing impaired, the orthopaedically and neurologically impaired. Few educational programs are available for people with other medical conditions such as cardiovascular disease, mental illness, epilepsy, respiratory disease, etc. Little remedial driver education is offered, either. Generally, there appears to be a much greater need for driver education, particularily in the over-school-age group, than can be met by readily available services.

An ideal, practicable model should fit into the current trends in education and licensing yet should optimize their advantages. The model does this. In describing the proposed system, the general roles of the participants will be discussed first. These are the roles as they should be defined in an operational system, not necessarily as they exist today.

- Driver/special education personnel in schools--These persons will train the young, beginning handicapped driver while in school. The driver training will be a part of the basic educational program. The training will begin early in school, and emphasize both the safety aspects and the development of the needed skills. The driving instructors themselves, should be specifically trained to teach the special populations they will encounter. If needed, the driver educators will be supported by special education personnel.

- Driver/special education personnel in rehabilitation centers and institutions (public and private)--These individuals will be similar to those described above. However, they will be more specifically trained to handle the types of specialized clients within their institutions. In addition to young drivers, they will be involved in the training (and, therefore, rehabilitation) of older drivers, some of whom have driven prior to acquiring their handicaps.

- Driver trainers in private driving schools--These trainers will serve a similar function to those listed above. They will train both young drivers and older drivers. Their role is to train those people who do not have access to driver training in the schools or institutions or need specialized training not offered there.

- Driver license examiner (DLE) or supervisor, or specialized handicapped driver license evaluator--These are the people, knowledgeable of evaluation of handicapped drivers, who form the front lines of driver license evaluation. They will initially see the handicapped driver and screen him according to guidelines supplied by the Department of Motor Vehicles (DMV). He will either grant a full license, grant a restricted license, deny a license, or refer the driver license applicant for the collection of additional information, or for a more specialized evaluation.

- Driver improvement analyst (DIA)--He is more specifically trained to evaluate and assist handicapped drivers. He could fill the role of a specialized handicapped driver license evaluator referred to above, or he could handle the more complex cases for the driver license examiner

(DLE). The DIA, therefore, could constitute one referral option available to the DLE. He will also assist the handicapped drivers who have special problems, such as a need for help in acquiring driver education or adaptive vehicular controls.

- License administrative staff--This group of people within the driver licensing agency will have the primary responsibility for retraining centralized data on handicapped drivers by handicap group and by individual drivers. This data will be collected for two reasons: (1) the group data can be used to help determine relationships between specific handicapping conditions and accident and violation rates; and (2) the individual data can be useful in making renewal licensing decisions for individuals (i.e., changes or removal of license restrictions and revocation of licenses altogether).

- Medical advisory board (MAB)--The medical advisory board personnel, consisting of appropriate medical and highway safety personnel, will have two primary responsibilities within the State: resolution of difficult individual cases and determination of additional license medical guidelines and medical criteria. In the resolution of individual cases, the MAB will receive referrals from driver improvement analysts, driver license examiners, and other specialized evaluators. The MAB will collect information on individual cases from DLE's and DIA's as well as private physicians and/or public health department personnel, along with driver record information, if available. In setting new licensing standards for specific medical problems, they will receive and interpret data from the license administrative staff, as well as from other sources, such as independent research studies and data from other states.

- Private physicians and public health department physicians--These persons will supply information to licensing personnel (DLE's, DIA's, or MAB's) concerning the extent of an applicant's condition. If a private physician is treating an applicant, then the information may come from him. If, on the other hand, the applicant has no private physician, he may elect to be examined by public health physicians for diagnosis and evaluation of his health. Information may also be supplied to driver education personnel to aid them in determining the most effective method of driver training.

- Motor vehicle inspector--He will have the responsibility of initially checking, and periodically inspecting, the integrity of adaptive controls used in vehicles. He will ensure that all vehicular devices critical to safe driving are in proper working order and are securely fastened to the vehicle. He will also determine if the devices meet operational standards for such equipment.

- DMV and other traffic safety research personnel--These are persons, specifically trained, who collect and analyze data on special populations. They either work directly for the Department of Motor Vehicles, or work for the Federal Government or private institution or companies. They will acquire data from the license administrative staff, or will collect information separately in their own experiments or projects.

- Police and emergency personnel--They will be trained to detect handicapped drivers who have been involved in accidents. Both will be prepared in an accident situation to provide special emergency treatment, if necessary, and to indicate the role of the impairment in the causation of the accident, if there is a role. Accident information will be forwarded to the license administrative staff.

- Legislative and judicial personnel--Both the legislative and judical personnel who deal with handicapped driver issues will be trained and kept abreast of the state-of-the-art of the information and research on special population drivers. The judical personnel will handle individual court appeals concerning DMV administrative licensing decisions. The legislative bodies will enact the legal framework and funding necessary for this integrated education and licensing system to function.

- Special population interest groups--These are the groups of persons (e.g., Epilepsy Foundation) particularly interested in the treatment and disposition of handicapped drivers. They will serve in helping to provide the various special population perspectives of the system. They will assist in supplying inputs as to the needs, desires, and capabilities of the handicapped to both education and licensing agencies. They will also be useful in assisting handicapped individuals in optimizing their access to, and interaction with, the education and licensing system. In addition, they can perform research of specialized interest to further the state-of-the-art.

- Relatives--These are the relatives of the drivers who have medical conditions. They are to report to licensing officials those medically impaired relatives who, they feel, require special attention in licensing. They will be knowledgeable as to their relative's driving restrictions so they may assist them in maintaining their desired level of mobility.

- General public--They will be informed of the system so that those who become disabled will know how to initiate the proper procedures in regard to the system. They will also be assured that all drivers who are licensed through this system, regardless of physical conditions, will be capable of driving safely.

There are three major candidates for entry into this education and licensing system. One group of handicapped persons learned how to drive when they were able-bodied, and then became disabled. These individuals are generally beyond the school-age and know the rules and the basics of driving. The remaining two groups of potential handicapped drivers never drove as able-bodied drivers. In the next group (and by far the largest), there are those who were born disabled or who became disabled prior to the legal driving age and want to drive at school-age. The third group of drivers are those who were, or became, disabled prior to beginning driving, but who are beyond school-age.

The first group of drivers already has knowledge and has developed skills relevant to driving. They may need to learn compensatory skills (e.g., if they have become musculo-skeletally or neurologically impaired), and/or they may need to learn specific precautions (e.g., if they have diabetes mellitus or cardiovascular disease). The drivers in this group already have valid drivers' licenses. They enter the education and licensing system by notification of licensing officials that they have conditions which might impair their driving abilities. The licensing officials are notified by the handicapped drivers themselves, their private physicians, police, emergency personnel, public health or hospital personnel or their relatives. They are then required to be immediately re-examined for their license by the DLE, or by specialized handicapped driver license evaluators. The applicants will be required to bring descriptive medical information from their physicians or public health departments with them to the re-examination.

The evaluators then assess the applicants. There are several possible decisions at this point: (a) no change in license status, (b) complete revocation of license, (c) change to a restricted license, (d) referral to the driver improvement analyst, (e) referral to medical advisory board, (f) require additional medical information prior to licensing, or (g) grant temporary license conditional upon receipt of remedial driver education by applicants with subsequent demonstration of driving capability. If an applicant feels that a change in the status of his license was unfair or unjust, he can request referral to the DIA or MAB; or he can appeal to the courts. If an applicant has been referred to the DIA or MAB, they will recommend a license decision to the DMV. If an applicant needs additional information concerning his medical history and acquires this information, he returns to the DLE for re-evaluation again. Finally, if an applicant receives remedial training, he also returns to the DLE for re-evaluation.

The next group of handicapped drivers are those who were disabled prior to the legal driving age and want to drive at school-age. These drivers have not developed basic drivers' skills and knowledge, and do not have legal licenses prior to entering the system. They enter the system in two ways. The first is through education. Those who take driver education in school, private institutions, or private driving school will be pre-screened and assessed as to driving potential, and branched into appropriate programs. If they are accepted into valid educational programs, they can then be candidates for a learner's permit. At this point, they enter the system from the licensing end by applying to the DLE for learner's permits. If they meet the State's criteria for license eligibility, they are given learner's permits. Upon successful completion of the driver education program, they can apply for full licenses by going through the complete DLE evaluation. Then the process becomes identical to the first group's process with some minor changes. First, their regular licenses are not changed since the full licenses have never been issued. Instead they are granted licenses or not granted licenses, and these can be either restricted or not. Second, they could not be granted temporary licenses, only extensions to the learner's permits conditional upon remedial education.

The exception to this process is the individual who does not receive special education from a school, institution or private driver school. He may be taught by his parents, relatives, or older friend. This driver would enter the system only at the licensing end.

The third group of drivers are those who have never driven, are handicapped, and are over school age. These drivers enter the system in a manner similar to the group above, but they do not rely upon driver education from the public school system. They are beginner drivers, and must start by learning all of the basics.

All three groups of drivers will enter the educational and licensing system. This is an integrated system with communication between all members. It is meant to allow full, adequate and specialized training of handicapped drivers, whether it is a complete driver education program, or a small remedial training program. The system is designed to fully evaluate driver applicants for licenses, and to require in-person renewal as medical conditions change. Conditional licenses are also an integrated part of the system.

In the past, most driver licensing was considered in the binary mode: the license applicant either received full license investiture or no license. Conditional licensing will permit the state to recognize the individual's need for mobility, while allowing it to exercise its statutory charge to protect public safety by offering licenses which qualify driving with respect to the traffic environment, special equipment, time, place, or other qualifications which the individual case may warrant. A very restricted license, for example, may only allow driving to work and for personal shopping through familiar neighborhood streets, during off-peak hours, and daylight. The issuing of limited licenses allows some mobility for many special population drivers who would otherwise have even greater mobility restrictions. Without the personal mobility offered by a driver's license, even a determined person may look forward to a life of dependency and limited personal growth. Under the restricted license scheme, a new driver with a stable condition can gain experience in a realistic traffic environment and may be able to earn a less restricted license in time.

On the other hand, a driver whose condition is not stable, and who is becoming more affected by his condition, may require frequent license re-evaluation and renewals. The faster a driver's condition changes, the more frequent the license renewal process must be. Since the evaluation of a person's risk potential occurs only at the time of license evaluation, a changing condition means a changing evaluation. The determination of the frequency of re-evaluation and license renewal will be made on an individual case condition at the time of the previous evaluation. This determination of renewal frequency will be made by the DLE, DIA, MAB or whoever makes the licensing decision in the individual circumstance. Most renewals will be in-person so that obvious condition changes can be noted, and so that appropriate tests, including road tests, can be administered.

It is quite possible that remedial training will be required before re-issuing a license if a person's condition has progressed. If new driving related disabilities develop during the course of a changing disorder, new compensatory skills may be needed before the license can be renewed. This remediation should attempt to increase skill levels to a point where conditional, or even full, licensing is feasible. Such training may be aimed at teaching or retraining specific skills (e.g., better visual search patterns for certain stroke victims; safe operating procedures for persons using special adaptive devices). Often, all that will be required is instruction in special precautions for the driver. For example, a diabetic may be warned to maintain a very specific diet so that his condition will not make him liable to a loss of consciousness behind the wheel.

An education and licensing system can only offer such features as remedial training and conditional licensing if special population drivers are known, and designated as such. Handicapped drivers can be detected upon initial application for a license, and during periodic renewal of all driver licenses. They can be detected by self-reporting, by asking appropriate questions during license application, through reporting by relatives, and by DLE's observing obvious signs and symptoms. For detection of other handicapped drivers who are either purposely avoiding detection, or who are unaware that they have potential disabilities for driving, there are several avenues of communication to the DMV.

First, the physician should report a patient who could be an unsafe driver, both for the driver's safety and for the safety of the general public. In order to mitigate the potential for jeopardizing the traditionally confidential patient-doctor relationship by the report, the legislature will legally require physicians reporting under guidelines established by the MAB. The MAB should consist of peers of the private physicians, and the MAB should be aware of the physician's difficulties. The reporting of a handicapped driver does not result in immediate revocation of a driver's license, except in especially severe cases. Instead, it calls for evaluation of the driver with the potential for maintaining a full license and/or remedial driver education and/or a conditional license.

In the same vein, hospital and public health departments should report potentially dangerous drivers. Police who, in the course of their normal routine, spot drivers who are involved in accidents or violations possibly caused by disabilities should report such handicapped drivers to the DMV. There also will be a requirement that the DMV establishes an interface or hotline between itself and citizens who, in the interest of public safety, may want to notify the agency about a relative whose driving may be hazardous.

To be totally effective, all components of the system must have open communication links available to insure that the special population driver is detected and reported, properly educated, evaluated, licensed (if possible), and reviewed periodically. This communication will permit records of the experiences of education and licensing to be kept and follow-up data on the performance of these drivers to be sought as a matter of due course. Specific research studies will be performed to address particular problems. This information will be collected, analyzed, and evaluated to constantly improve the performance of the system.

IV. REVIEW OF THE DRIVING BEHAVIOR OF SPECIAL POPULATIONS

A. Description of the Driving Task

In order to establish human performance requirements for safe driving, more must be learned about the driving task. Even a cursory examination of automobile driving reveals a wide range of variables (such as the vehicle, the highway-traffic environment, and the human component) which combine to form a complex human performance situation.

These interactions, most notably the not well understood cognitive and motor aspects of human behavior, have hindered the empirical study of driving. Under the present contract, it was not feasible to develop a formal model of driving behavior or to conduct a comprehensive review of the work done in this area. However, in order to evaluate the literature on psychomotor and driving behavior of "special populations," the project staff reviewed a number of articles and technical reports describing the driving task. We found that the experts in traffic safety and human performance generally agreed that, given the available information, human performance requirements for safe driving cannot presently be defined for either normal or handicapped persons. (Waller, 1975; Sipajlo, 1975; Murphy, 1975; Huffman, 1975; Henderson and Burg, 1974; Less and Manus, 1973). As Henderson and Burg (1974) have pointed out, this certainly cannot be considered a criticism of the work that has been done but rather an indication of the complexity of the problem under study. However, the importance of the attempt is underscored by the fact that poor human performance is considered by many (but not all) investigators as causing the largest percentage of automobile accidents.

Recently, McKnight, in work sponsored by NHTSA, attempted to define and rank in criticality human driving behaviors (Driver Education Task Analysis, HumRRO, 1971) in order to develop driver education training objectives. A comprehensive analysis of the literature identified over 1500 driver behaviors which were grouped into relevant driver tasks. These tasks were reviewed by a group of nearly 100 traffic safety experts in order to establish their importance for subsequent treatment in driver education courses (Safe Performance Curriculum, Pre-Driver Licensing Course, HumRRO, 1974). While there was a critical need for this study as a base both for future research and for driver education curricula development, the study did not demand a level of analysis which would allow the development of valid human motor, sensory, and cognitive requirements for safe driving.

In the hope of defining these requirements, different hypotheses about the interaction of human psychomotor processes have been investigated. In an attempt to define the visual requirements component for automobile driving, Henderson and Burg (1974) surveyed the literature on vision thought to be related to the driving task. Using the Driver Education Task Analysis (McKnight, et al, 1971), they systematically examined the visual performance parameters which were judged to be important to individual automobile driving tasks. As a result of the literature review, ten visual functions were identified as being potentially useful for the development of vision requirements for licensing procedures. After an examination of the Driver Education Task Analysis, six (*) of the ten visual functions remained as being relatively high in importance to driver licensing:

- Static Acuity*
- Perception of Angular Motion*
- Perception of Movement in Depth*
- Dynamic Visual Acuity*
- Visual Field*
- Saccadic Fixations*
- Glare Sensitivity
- Pursuit Fixations
- Steady Fixations
- Visual Performance

Henderson and Burg (1974) and Ellingstad (1970) stated that it is generally recognized that the driver receives most of the information he uses through his visual sense. At a gross level the auditory senses are usually only considered important in the detection of warning devices (horns, bells, wind, or automobile system changes). In Henderson and Burg's review of the Driver Education Task Analysis (McKnight, et al, 1971), only one item was found which had significant auditory requirements. This may have been more a result of the analytical procedures used in the Driver Education Task Analysis than a valid estimation of hearing's relevance to safe automobile driving. Henderson and Burg's (1974) experimental work did point out, however, that the conditions under which auditory stimuli are likely to be sensed by an individual with good hearing (car at idle or low speed) are the same conditions under which a driver with hearing loss will have greater opportunity to use his other senses and thereby compensate for his loss of hearing. In contrast the authors noted that the interior and exterior noise levels at higher speeds are likely to mask most auditory warning stimuli even for the non-hearing impaired person. Based on their work, the authors felt that auditory requirements screening of driver license applicants would not be worthwhile. Little is known about the complementary interaction of auditory cues with other sensory cues in the driving task. In a more recent simulator study, the deletion of a velocity-dependent audio cue (engine noise) did appear to contribute to the driver's inaccuracy in maintaining an instructed vehicle speed but this deletion was not statistically significant (McLane and Wierwille, 1975).

Two other sensory channels potentially contribute to the safe operation of the motor vehicle. These are the vestibular and kinesthetic senses. These sources of information to the driver are often overlooked in the description of the driving task. Ellingstad (1970) noted that cues from these senses are important for controlling the automobile both in acceleration and deceleration along the longitudinal axis of the vehicle as well as in transverse acceleration developed during cornering and skidding. He stated that, although not tested, it seems apparent in a skidding situation that corrective response is initiated well before visual detection of the pivotal motion. McLane and Wierwille's (1975) simulator work does suggest that these motion cues to the vestibular and kinesthetic senses do significantly influence driver performance.

Since the information used by the driver comes from three sources (vehicle, highway-traffic environment, and operator), driving behavior has been described as a dynamic situation where the operator must actively search for and integrate information. A number of human mental processing models (Gibson, 1938; Learner, 1960; Schlesinger, 1967; Briggs, 1968) have been suggested to describe this process. Generally, these models use visual input as their source of data along with four mental activities, namely: attention/search, perception, decision making, and motor coordination. Many suggested measures for each of these specific abilities have been directly or indirectly studied in relation to accepted criteria of good driving performance (e.g., number of actual accidents or actual driver violations). Since ethically one cannot place human subjects in hazardous situations, the direct testing of these hypotheses has been methodologically limited. However, much indirect hypothesis testing has been accomplished using laboratory psychomotor testing (e.g., simple and complex reaction times). While laboratory work allows good experimental control over the variables under study, the direct applicability of the findings to driving is questioned. The use of simulators improves the transfer of experimental findings, but there is always the question of whether there is sufficient fidelity (e.g., feedback, environmental hazard) in the simulator task to allow the development and acceptance (legal and social) of human performance licensing standards. Epidemiological studies also have problems, since the results are always subject to the usual uncontrollable field study variables; not the least of these is the use of data tuned to administrative rather than research needs. Acceptable epidemiological work requires control for age, sex, exposure, driving experience, and often other variables.

For the above reasons, much of the investigation into human mental processes and driving has been done in the laboratory or on simulators. Zell, Rockwell and Mourant (1969), using eye movement recording instruments, studied the search and scan fixation patterns of drivers. They have demonstrated that all persons do not share the same forward viewing strategy. New drivers demonstrate one kind of search pattern while experienced drivers demonstrate another.

The perceptual aspect of driving (identification of relevant cues and relating these cues to pertinent stored information, Ellingstad, 1970) has been difficult to describe and to measure. The automobile-passing task has been described as a perceptual judgment task. Jones and Heimstra (1964) found that drivers were likely to underestimate the time required for one automobile to pass another automobile. A similar concept related to the human mental processes and driving is decision making or risk taking. It, too, has been very difficult to isolate and to test directly.

Often included in discussions of human mental processing and driving are attitudinal studies. Attitudes about driving are thought to be predictive of driving performance (Harano, Peck, McBride, 1975). For handicapped persons, attitudes are often discussed as especially important and predictive of compensatory and safe driving performance.

Many investigators have studied motor performance. In these studies, steering-wheel reversals, speed changes, direction changes, and other univariate (Greenshields and Platt, 1967) or multivariate (Ellingstad, 1969) output performance measures are used to discriminate between novice and experienced drivers (Ellingstad, Hagen, and Kimball, 1970) or between high accident and low accident drivers (Greenshields and Platt, 1967). Recently, in a large multivariate study, Harano, Peck, McBride (1975) found that simulator based performance measures (driver's braking, accelerating, and steering) did not discriminate between high and low accident rate drivers.

Many human performance models related to driving have been studied. Fergenson (1971) found that high accident drivers performed significantly more poorly on an information processing choice/reaction time test than did either low accident or high violation drivers. Similarly other investigators (Brown and Poulton, 1961; Posner, 1966; and Helander, 1975) have suggested that safe driving may be related to drivers' differing capacities to process information. Helander's work on environmental and human perceptual complexity capabilities may be able to isolate critical, high accident situations so that basic work such as Kellerman's (human energy expenditure, 1971) can be done.

As previously noted, the project team's review of the literature on the driving task and discussions with experts in the field revealed that the driving task has not been described in enough detail. Even in the area of vision, which has been closely scrutinized, there has not been sufficient information available to establish driver license screening requirements which could apply to either normal or handicapped persons (although current on-going research sponsored by NHTSA may establish these requirements). However, the efforts of McKnight (1971), Helander (1975), and the new multi-disciplinary accident investigations (Indiana University Multi-Disciplinary Accident File) will hopefully direct and coordinate future efforts to define human performance requirements.

B. The Review of the Driving Behavior, Licensing and Driver Education Literature for Handicapped Persons

In this section, the following information will be presented for various handicapped groups: private and commercial driving behavior; driver education and assessment materials; present state laws regarding licensing; relevant medical opinion regarding examination and licensing; and any complicating factors which might relate to licensing, such as the use of therapeutic drugs. The terms used will be those which were used by the original investigators or authors to classify and describe groups of persons under study. The same practice will be followed for their statement of conclusions. In summarizing the work in the field, this document will cite as reported all the experimental evidence pertaining to the driving performance of handicapped persons as well as any stated, relevant anecdotal remarks. This would include, for example, the author's noting that educable mentally retarded drivers (EMR) appeared more easily flustered by a complicated driving environment than normal drivers.

Warner (1970) offers a good review of many research criteria involved in the study of traffic safety and accident research. Throughout this literature review, the project staff has been careful to evaluate the experimental rigor of each study in light of these criteria. For laboratory work, this included unbiased samples, sufficient sample size, experimental design, proper analytical treatment, and appropriateness of conclusions. For epidemiological studies, this usually meant control for variables such as age, sex, exposure (annual mileage and similarity of traffic environment), driving experience, and socioeconomic status.

For reporting purposes, we have classified each study in terms of experimental rigor into four categories: case study, survey, and experimental studies (laboratory and field) which were either "somewhat" or "well controlled." The case study is self-explanatory. A survey is defined as a descriptive study containing more than ten respondents and lacking direct comparison with a control group. A study which has some experimental rigor, for instance, control for sex and age but not exposure (annual mileage driver), would be classified as "somewhat controlled." Studies with more than two relevant controls and no major design or analytical flaws (e.g., grouping a number of different handicaps together) would be classified as "well controlled" studies. Although minor deviations may be noted in classifying a particular study, the language used will conform to the definitions presented in this paragraph.

There are many examples in the literature where experts in the field report their experience and recommendations without data. This includes the recommendations of state medical advisory boards and special conferences. When these experiences or recommendations are reported, we will endeavor to document the source of the opinion as well as the qualifications of the experts.

1. Undifferentiated Handicaps

There is a large amount of contradictory opinion about the driving performance of handicapped persons. One of the reasons, as West (1963) noted, was the tendency of many researchers to assume that the physical impairments of drivers were important in the causation of accidents. Some observers (West, 1963; Ysander, 1970) felt, however, that very little good evidence had been collected either to confirm or to deny such an assumption. Much of the early research did not control for age, sex, experience, or exposure, and often used heterogeneous rather than homogeneous experimental groups. Valid comparisons, therefore, were nearly impossible to make. Often the only evidence presented were case reports of "safe and successful" or "dangerous" handicapped drivers (McKee, 1954; Altobelli, 1964; Schweikert, 1969).

The reports of general surveys (Finesilver, 1970; Connecticut Department of Motor Vehicles, 1970; New South Wales Department of Motor Vehicles, 1971) or state licensing screening programs (Wilbar, 1965; British Medical Journal, 1966) were not much better. Finesilver surveyed over 400 safety professionals, licensing officials, and judges. He reported that 71% rated handicapped drivers as average or better than the general public with no one having rated them as hazardous drivers. The Connecticut DMV looked at the driving records of approximately 4,000 of the State's licensed handicapped drivers. They reported that none had been guilty of serious or dangerous violations and that none had any traffic problems as a result of his or her physical handicap. With the same kind of evidence, the New South Wales DMV reported that physical handicaps of one type or another had not been found to be related to accident rate. Moreover, Wilbar (1964 and 1965), reporting on the voluntary driver licensing screening program of Pennsylvania, stated that .04% of those 16 years of age and 0.7% of those 61-93 years of age failed their physical examination. Similarly the British Medical Journal, citing information from West Germany and Sweden, reported road traffic accidents due to chronic disorders at rates of 0.6% and 0.8%, respectively.

Even in somewhat more controlled studies, differentiation between handicaps with differing functional disabilities was not always reported. Herner and Ysander (1962) compared the accident experience of 120 drivers with "progressively chronic disease conditions" to that of a randomly chosen control group (matched for age, sex, license-holding period, and exposure). They found no differences. Buttiglieri, Guennette, and Thomson (1969), in a somewhat controlled investigation, grouped 798 medical-surgical patients and found, with respect to accident experience, that they did not differ significantly from either a random sample of male California drivers or a selected group of psychiatric patients. With respect to violations, both patient groups had significantly higher violation rates. Baker and Spitz (1970), using autopsy evidence, found no correlation between driver accident responsibility and evidence of disease or physical disability.

In terms of education for the "handicapped" there is a similar problem. Many authors simply reported that handicapped students require more instructional time (Gutshall, 1962), that they fatigued more easily (Garris, 1973), or that they required more positive re-enforcement than normal driver education students (Stiska, 1972). There was little specific information on the educational needs of persons with particular handicapping conditions.

Most programs can only recommend general educational guidelines for the handicapped learners:

- Beware of reading deficiencies and gear handicapped driver education materials to low reading levels (Mullin, 1974; Misner, 1975).
- Modify normal teaching techniques to develop programs with high repetition (Mullin, 1974).

- Be sensitive to the motivational and emotional problems of students since even minor failure can develop into a major emotional problem (Stiska, 1972; Nemarich and Vellerman, 1969).

- Use a simulator in order to gain a familiarity with automobile controls before "behind-the-wheel" instruction (Misner, 1975; Bartels, 1975; Mullin, 1974).

- Use a special education instructor or a driver education instructor who is experienced in working with the handicapped (Bolinger, 1970; Reynolds, 1975).

- Shorten normal instructional time to a maximum of 20 minutes (especially on-the-road instruction) (Fisher, 1975).

A few programs offered separate tracks into which they placed persons with different degrees of disability. Bolinger (1970) described four tracks:

- Track A: Students obtain learner's permit on their own; behind the wheel instruction is done by traditional driver education instructor.

- Track B: Traditional driver education program with only supportive assistance from special education teachers.

- Track C: Use of special education instructor with the traditional driver education teacher in a supportive role.

- Track D: Additional or supplemental assistance is given for behind the wheel instruction.

Most programs used individualized instruction and simply adapted curricula from normal driver education materials as required.

Individual programs were likely to have assessment or driver education screening procedures which were unique to their staff. These ranged from very informal (response to verbal questioning, noting ocular control of fixation time during an interview--Fisher, 1975) to the extensive use of formal diagnostic tests (WAIS, WISC, Bender Gestalt, Siebricht Attitude Scale, Raven Progressive Matrices). More sophisticated testing was dependent upon either the availability of professional assistance (psychologist) or the experience and discretion of the driver education personnel. In some programs, this assessment was done in simulators (Long, 1974; Brown, 1975). Later, the driving instructor, during behind-the-wheel instruction, must make another in-car assessment. This may be the noting of "perceptual" deficits or emotional problems behind the wheel (Sipajlo, 1975).

Historically, the Uniform Vehicle Code has had general provisions which state that a state department of motor vehicles shall not issue any driver's license to, nor renew the driver's license of, any person:

- Who has previously been adjudged to be afflicted with or suffering from any mental disability or disease and who has not at the time of application been restored to competency by the methods provided by law.
- When the commissioner has good cause to believe that such person by reason of physical or mental disability would not be able to operate a motor vehicle with safety upon the highways.

All but ten states have comparable statutory provisions for both of these general provisions.

The validity of these statutes permitting the denial, suspension, revocation, or cancellation of a driver's license for physical disability does not appear to have ever been seriously questioned. It is generally thought to be justified under state statutes empowering licensing administrators to make provisions designed to limit the operation of motor vehicles to those who are thought competent to do so (American Jurisprudence, Second Series). More recent court cases may suggest that a state may be required to justify its licensure procedures in order to insure special populations' equal rights under the law.

2. Mental Retardation

Mental retardation has been described in a variety of ways from degrees of impairment in activities of daily living (Committee on Rating of Mental and Physical Impairment, 1966) to degrees of intellectual functioning based on IQ (Committee on Nomenclature and Statistics of the American Psychiatric Association, 1968; U.S.D.H.E.W., 1968). Its causes are unknown but can range from genetic defects to traumatic injury. In driver performance research, many terms are used to describe this condition: mental retardation, mental deficiency, educable mentally retarded (EMR), educable mentally handicapped (EMH), imbecility, low intelligence, etc. Ocassionally, psychomotor deficits are described as being related to intelligence (Banks, 1974; Dawson, 1967; Phillips, 1967; Wagner and Schaff, 1968). The research and opinion described in this section contains a composite of many different perspectives and definitions of this handicap.

It has been William and Little's (1966) experience that the mentally retarded student can be taught to drive. Kesterson (1975) said that IQ level alone is not predictive of a person's ability to drive. In agreement Wallner (1974) stated that it was not the individual's mental capacity but how he used his abilities and how he was taught which determined his ability to drive. Adserballe (1974) and Latimer (1975) concurred but both felt that the lower the IQ, the lower the chances of learning to drive safely. Johnson (1975), as a rule-of-thumb, suggested that students with an IQ below 60 will have little success in learning to drive; but he stated that this rule is somewhat dependent on which of the IQ measures is low. The American Medical Association suggested another rule-of-thumb. A person who was mentally retarded and who cannot learn to read was likely to have difficulty learning to drive safely.

Long (1974) reported that three mentally retarded individuals were assessed as to driving potential on a driving simulator. All three passed and were referred to a driving school. In West Germany, Sluga (1968) questioned 33 people with driver's licenses who were mentally retarded. He found that the handicap appeared unrelated to automobile accidents causation. In Sweden, 43 mentally retarded persons were issued tractor licenses and 27 were issued licenses to drive a car over the years 1966-1970 (Beskow, 1973). Most had IQ's between 60 and 80. As of 1971, three had auto accidents and two had tractor accidents. Only ten still drove cars, while 18 still drove tractors. Of 15 persons mentally deficient who were denied licenses but still drove tractors, seven had accidents. Their IQ's ranged from 60 to 30. In 1955, Canty reviewed 812 cases of problem drivers. He found 30% were mentally retarded. Hampel (1962), in a survey of over 1,000 people, came to the conclusion that there was a relationship between IQ and safe driving. Of those people who caused accidents the mean IQ was 91. People who had frequent traffic violations but did not cause an accident had a mean IQ of 86. Those who failed the driving test more than once had a lower than normal IQ; Hampel pointed out that the driving test was a measure of driving ability.

In a somewhat controlled study (State of Illinois, 1974) 35 EMH students' driving records were reviewed over a five year period (1968-1973). These drivers were in 41% more accidents than the average for all other drivers in Illinois. However, in a follow-up study from November 1973 to November 1974, these 35 drivers were involved in no collisions. Gutshall's fairly well controlled study (1968) concluded that a group of drivers with lower intelligence (mean IQ 73) had a higher number of combined accidents and convicted traffic violations than average IQ drivers, but the difference was not statistically significant. The low IQ groups had more points for violations (other than speeding) than either the average or above average IQ groups. Self-reported mileage driven per year also indicated that the low intelligence groups did spend more time in their cars.

Eight EMR's meeting intelligence and performance criteria (perception and reaction time) in a driver education program were compared with eight students who were intellectually normal. (Pappanikov and Bowan, 1960). The EMR's had mean IQ's of 70 on the verbal (WAIS) and 80 on the performance (WAIS). The normal group had generally superior vision, distance judgment, and glare recovery. The groups were equivalent in color vision. The EMR's had slightly better reaction time. All of the low intelligence group passed the written driver examination. Two passed the road test on the first attempt; two passed on the second attempt; one passed on the third; and three never passed.

In a more recent study, Egan (1967) compared 18 EMR and 18 randomly selected regular students over a four-year period. The ages ranged from 16 to 19 with IQ's ranging from 47 to 75. He found that regular students had superior distance judgment (distance between automobiles), better complex reaction time and steadiness, and better knowledge of traffic laws and regulations. Both groups were equivalent on field of vision, color vision, visual acuity, and night vision. With considerable coaching the EMR's passed the driver license test. The lower intelligence group had difficulty with speed control, often because they failed to watch the speedometer. They also had difficulty in making quick and accurate appraisals of approaching obstacles so they could make compensating adjustments in their driving. The EMR's group, by comparison, had twice the number of accidents. Egan's conclusion was that the EMR operates an automobile at a marginal level.

Bologa, et al., (1971) compared 349 EMR's with 443 normal (N) high school students. All had valid driver's licenses. The ages ranged from 16 to 20 and the two groups were not matched. The following conclusions were reached:

- There was no difference between the groups for speed, steering, signaling, or braking on a simulator and no relationship to accidents and violation.

- The EMR's reacted slower than the normals to a majority of emergency situations involving braking and steering.

- The EMR's drove an average of one year longer than the N's.
- There was no relationship between miles driven per year and accidents and violations for EMR's.
- Fewer EMR's had driver education than normals. For the EMR's there were fewer accidents and violations when they had driver education.
- Even though there was a difference between the mentally retarded group and the normal students on a personality questionnaire, there was no relationship between the questionnaire and accident and violation rates.
- In general, for both groups, the better the visual acuity the more likely they were to be involved in accidents and violations.
- For the EMR's only, the more accurate they were in perceiving situations close to them (ability to judge distance), the less likely they would become involved in accidents and violations.
- There was no relationship to accidents or violations and color vision for either group.
- There was a negative relationship between good scores on visual attention, depth visualization, recognition of complex detail, total number of tests passed, and percentage of correct variables of the Wilson Test of Driver Selection and low accident and violation rates.
- EMR's who did well on the recognition of simple detail and eye-hand coordination on the Wilson Test were less likely to be involved in accidents and violations.
- All high scores for the Wilson Sub-Tests were related to low accidents and violations for normals.

Ransford (1972) felt that there may be problems in licensing mentally deficient individuals to drive a car. Adserballe (1974) was of a different opinion. In a Danish article he stated that if they are able to pass the driver test then they should be able to drive. The Industrial Medical Association (1966) suggested that each commercial organization should establish its own criteria for the level of intelligence needed. It recommended, however, that a commercial driver be able to read and write and to interpret signs. He should be at least a grammar school graduate and high school would be preferable.

The medical guidelines for East Germany (Koschlig, 1974), recommended that people who exhibit severe or fairly severe mental deficiencies should not drive. For the mentally retarded who have a less severe handicap, permission can be given to drive commercially and privately if outstanding social adjustment, responsibility, and ability to function in society can be proven. The Nova Scotia Guide for Physicians (Nova Scotia Medical Society, 1965) stated that people with an IQ below 80 are not fit to operate a motor vehicle. The American Medical Association disagreed with this. It recommended that drivers with IQ's below 70 may not be able to make accurate decisions under emergency situations and they, therefore, should be kept away from heavy traffic or stressful conditions and not be allowed to drive commercial vehicles. The Canadian Medical Association (1974) was in general agreement but did not specify an IQ level. The Quebec Ministry of Transport (1973) required a driver to have an IQ of at least 70. If his IQ was between 70 and 80, he may only drive a private vehicle. Beskow (1973) and Wallner (1974) reported that Swedish law has removed IQ limits (used to be an IQ of 65). Now each individual has to be evaluated as to his emotional maturity, common sense, social adaption, technical ability and motivation.

The Uniform Vehicle Code states that a person will not be issued a license or have one renewed if: (a) he is suffering from a mental disability and has not been restored to competency, or (b) if the commissioner has good reason to believe that a person, because of his mental disability, would not be able to operate a motor vehicle safely on the highways. Forty-one states have similar codes. For the legal profession, Words and Phases (1965) defines an "incompetent person" as an individual who is so mentally impaired that he is incapable of driving a motor vehicle.

Mentally retarded students are screened in various ways for entrance into a driver education program. Bloomer (1975) reported that her students (IQ below 75) were evaluated by a teacher, by a battery of psychological tests as well as by a guidance counselor prior to acceptance into a driver education program. Johnson (1975) reported that students who can successfully ride bicycles, who have a high level of independence and who have the support of their parents and peers, generally are the best candidates for driver education. According to Mullin (1971), and Bologa, et al. (1971), pupils should be screened by teachers, school health services (school doctors and nurses), guidance counselors, and school psychologists. Pappanikow and Bowan (1959) have five criteria for entrance into their program: (1) IQ of at least 70 on the performance sub-tests and 60 on the verbal sub-tests of the Wechsler, (2) no lower than 4.0 grade level on the California Achievement Test, (3) be at least 16 years of age, (4) be medically fit, and (5) meet passing score on perception and reaction time tests.

Dick (1971) reported that from half to three-quarters of the EMR's can succeed in a regular driver education program, but they must repeat the course two or three times. Little (1966), with special classes, estimated that it takes three to five times longer to teach EMR's than it does to teach normal students. Bloomer (1975) reported that each of her students spends a total of 30 hours driving on the road (her students all were below a 75 IQ). This is broken down into 30 minutes of observation and 30 minutes of driving, as well as 30 minutes of classroom learning daily. Pappanikow and Bowan (1960) gave their students a total of 80 hours of classroom instruction along with 18 hours behind the wheel. Only 30-60 classroom hours, along with 10-60 hours of in-car instruction, were used in the program reported by Oellerich and Latimer (1972).

One aspect of driver education for the mentally retarded is the use of simulation. It is used quite frequently and many find it useful. (Oellerich and Latimer, 1972 and Johnson, 1975). McPherson and Kenel (1968), in an experimental study found that EMH's (IQ 55-77, mean of 66) perceptual abilities improved with simulation instruction. They also found that the higher the IQ (they also studied average and above average IQ students) the greater the improvement in perceptual ability through simulation.

Bolinger (1970) described a four-track program that can be used for teaching EMR's: (1) students obtain learner's permit on their own, behind the wheel training is performed by a traditional driver education teacher; (2) traditional driver education program with only supportive assistance from special education teacher; (3) use of special education instructor with the traditional driver education teacher in a supportive role; (4) additional or supplemental assistance given for behind-the-wheel instruction.

In a symposium on driver education and the EMR (Dick, 1971), it was concluded that a pre-driver education course should be offered for EMR's before they begin the regular driver education course. This pre-driver education course should be presented by the special education teacher. While the regular driver course is being taught, the special teacher would stop teaching driver education so that the EMR's do not become confused. The special teacher could, however, provide reinforcement to the EMR while the regular course is progressing. For the most part, regular driver education course materials can be rewritten for the mentally retarded students' reading level.

McPherson and O'Leary (1969) mentioned that there are a number of techniques a special education teacher can use in teaching driver education: concept reinforcement, observation and re-teaching, team teaching, teaching solely by the regular driver education instructor, and driver education taught solely by the special education instructor. Having an instructor with certification in both driver education and in special education can be an advantage.

Oellerich and Latimer (1972) described three different courses for driver education for EMR's: (1) a basic course in driver education; (2) an advanced course of driver education; and (3) a course concerned with pedestrian and vehicle passenger safety. Mullin (1974) and Bologa, et al., (1971) described a curriculum as follows:

- 9th grade
  - screening of students
  - teaching basic vocabulary related to driving
  - reading regulations and procedures of driving
- 10th grade
  - classroom theory of driving
- 11th grade
  - practice driving on simulator, driving range and street
- 12th grade
  - refresher course.

McCune (1970) felt that state traffic laws, traffic signs and symbols, reading questions on a driver examination, responding to verbal or written questions about driving, driving a car, and applying traffic laws were topics that needed to be taught to mentally retarded in a driver education course. Curriculum materials for teaching driver education to EMR's were available (Michigan Department of Education, 1968; Latimer, 1975, Gracewood State School and Hospital; and State of Florida, for example).

Stiska (1972) emphasized the importance of positive reinforcement schedules which will aid the students in learning the materials. He also suggested that lessons should not last more than 20-30 minutes since EMR's have limited attention. McCune (1970) made the point that the mentally deficient have difficulty learning complex materials in an incidental manner, while state driver examinations measure only minimal knowledge on the assumption that drivers will acquire additional knowledge incidentally. Therefore, acquiring and applying the more subtle aspects of the traffic laws requires a relatively structured driver education program. Mullin (1974) recommended that special driver education instructors should be sensitive to individual reading deficiencies, provide reading material at the appropriate level, and build in a large amount of repetition. For driving practice he stated that manipulative and perceptual skills should be developed first. One method for the development of manipulative skills has the student wearing a blindfold while practicing the use of the controls. The EMR's need much practice, and the key points of driving need to be emphasized. McPherson and O'Leary (1969) pointed out the problem of poor transfer of learning from the classroom to the real driving situation. They suggested that whenever possible, classroom and on the road training should be integrated and taught concurrently.

Latimer (1975) mentioned that even if the EMR's are not given driver licenses after they have completed driver education, it is important for them to understand traffic from a safety point of view. Pappanikow and Bowan (1959), stated this in the goals of their driver education program: establish respect for hazards of automobiles, both as an operator and as a pedestrian; develop good traffic attitudes of the potential driver; increase a general interest in school; and develop safety aspects for both drivers and pedestrians.

3. Mental Illness

There are many types of mental illnesses ranging from personality disorders, through psychoses and neuroses, to psychophysiologic disorders (American Psychiatric Association, 1968). Obviously they are too numerous to describe in this report. The reader of this report is cautioned that diagnosis of mental illness is difficult and sometimes unreliable. In addition, although the nomenclature used in one study being reported may be the same as in another study, there is no assurance that two studies by different people at different times use the same diagnostic criteria.

Ransford (1972), reporting in Canada on Medical Factors in Traffic Accidents, stated that there is no good information on psychiatric problems. While there is not a large amount of definitive information, there are some research studies on driving performance, on the therapeutic drugs associated with mental illness, and on guidelines for licensing. One study even discussed the psycho-sexual aspects of people who were responsible for traffic accidents (Schuman, 1972).

Sluga (1968) stated that psychopaths and neurotics are dangerous drivers and have high accident rates. Canty (1955), in a review of over 800 cases of problem drivers, reported that 51.2% had mental disorders (psychotic: 2.0%, psychoneurosis: 2.7%, personality pattern disturbances: 12.7%, personality trait disturbances: 32.2%, sociopathic personality: 1.6%). However, the effect of mental illness on driving ability and the role it plays in the causation of traffic accidents is difficult to evaluate (Berger, 1975). Berger cited two cases of paranoid schizophrenia, two cases of neuroses and a personality disorder in which the illness was the cause of their traffic accidents. Writing in the South African Medical Journal, Cheetham (1974), felt that the following types were likely to be involved in traffic accidents:

- psychopathic people who are impulsive, aggressive and lacking in conscience who use the automobile as a weapon or exhibitionally;
- hypomanic people who are described as being impulsive, aggressive, lacking in judgment, without thought and care for others, and unable to tolerate frustrations; and
- psychotics and near psychotics who lack judgment and insight and frequently are out of touch with reality.

In contrast to these opinions, Ian Hector (Kenyon, 1970) believed that major psychotic illness contributes very little to accidents.

In the New Zealand Medical Journal, three cases were cited where persons who were diagnosed as psychopathological were involved in automobile accidents which appeared to be suicides (Grimmond, 1974). MacDonald (1964) also presented cases where suicide and homicide are associated with automobile driving. He concluded that both suicide and homicide are attempted more frequently with automobiles than is generally recognized. Thirty-three psychiatric patients previously diagnosed as suicidal were compared with 27 other psychiatric patients (Selzer and Payne, 1962). The suicidal patients had more than twice the number of traffic accidents per person than the others. In a somewhat controlled study, 96 surviving and deceased drivers responsible for fatal accidents were compared to a like number of controls (Selzer, 1969). The drivers involved in fatalities exhibited significantly more psychopathology (41% vs. 17%) and social stress (52% vs. 18%) than the controls. In a sociological investigation Porterfield (1960) concurred since he found positive relationship between rates of death from motor vehicle accidents and suicide and homicide in the 60 largest metropolitan areas in the United States.

However, the driving records of 165 patients admitted to a neuropsychiatric ward were analyzed for the three-year period prior to their admittance (Buttiglieri and Guennette, 1967). Their accident and violation rates were not significantly different from that of a randomly selected sample of normal drivers with the same mean age. In another article in 1967, Buttiglieri and Guennette (in Perceptual and Motor Skills) compared the driving performance of 361 male neuropsychiatric patients to all male California drivers. Over the three-year period prior to hospitalization, the patients had similar accident and violation rates when compared to the other drivers. However, the frequency of accidents and violations for the six month period preceding hospitalization was higher than would have been expected.

Eelkema et al. (1970) studied the driving records of 238 patients discharged in 1960 from a mental hospital and compared them with a control group of normals matched for age, sex and county of residence. The following results were obtained: (1) psychotic and psychoneurotics had a higher accident rate than controls before 1960, but were safer than controls after discharge; (2) people with personality disorders had the highest accident rate before 1960 and tended to show only minimum improvement after discharge; (3) hospital dischargees have a higher accident and violation rate per hundred driver years than controls; (4) male psychotics and psychoneurotics increased their violation rate after discharge compared to pre-1960 performance, and they had a higher rate than controls; (5) female psychotics improved their violation rate after discharge; (6) there is a significant difference in suicide attempts between patients with single car accidents and those with no accidents; and (7) there is no relationship between homicide threats, attempts and successes and driving accidents.

One hundred thirty-five patients hospitalized for stomach or duodenal ulcers were compared with the Ontario male driving population (Smart and Schmit, 1962). The ulcer patients had had significantly more accidents per person than the companion group. Selzer et al. (1968) compared 96 drivers causing fatal vehicle accidents (F drivers) with 96 drivers matched for age, sex and home county. The F drivers had more psychopathology than the controls--more paranoid ideation, suicidal proclivity and clinical depression. They also showed a higher level of social stress--more personal conflict and vocational-financial stress. Twenty percent of the F drivers also had acutely disturbing experiences (usually quarrels) within six hours prior to the fatality. In a study (Washington, D.C. DMV, 1973) of medically impaired drivers, the poorest drivers were those considered mentally ill--anxiety neurosis, depression neurosis and schizophrenia. Waller (1965) found that in an age adjusted comparison between 194 mentally ill drivers and a control group of 922 California drivers, the mentally ill drivers had more than twice the number of accidents expected and 1.8 times the number of violations.

Perrine (1974) reported, after a review of the literature on therapeutic drugs and driving that, to date, there has been no determined effort to associate the use of psychoactive drugs by drivers with specific driving errors or with responsibility for accidents. While this is generally true, there are a few studies and opinions on the effects of some drugs used for therapeutic reasons for the mentally ill. The next few paragraphs describe this literature, specifically discussing tranquilizers, sedatives and antidepressants.

Ataractics (or tranquilizers) can be divided into seven categories (Physician's Desk Reference, 1975). The driving performance literature dealt with only four of the seven: phenothiazines and combinations, meprobamate and combinations, butyrophenones and combinations, and other types. Keilholz and Hobi (1974) stated that tranquilizers are of interest to traffic medicine since they produce fatigue, are muscle-relaxing and their effect is increased by alcohol. Cheetham (1974), in a South African journal, reported that high doses of tranquilizers may cause a person to be euphoric, exhibit a "don't care" attitude, possibly become sleepy, or suffer from a sudden attack of low blood pressure with subsequent anoxia and loss of critical faculties. Waller (1972) stated that there was anecdotal evidence indicating that some individuals are involved in roadway accidents because of the effects of tranquilizers.

There were several articles that discussed the ataractic phenothiazine. Perry and Morgenstern (1966) stated that people who take phenothiazine type tranquilizers may have trouble driving. Patients who were on phenothiazine performed the poorest in reaction time tasks thought to be related to driving (Savage and Wilkinson, 1971). In 1963 Brandaleone suggested that chlorpromazine could produce drowsiness which could affect driving in some patients. It was Wenckstern's (1964) opinion that doses of more than 75 mg. of chlorpromazine should preclude driving, and that 50 mg. influences driving ability. This same drug, with a delayed onset, impaired performance on a simulated driving task (Loomis and West, 1958 as seen in Nichols, 1971). While Weatherall (1959) found that prochlorperazine taken at 10 mg. twice a day had no effect on simulator performance, he noted that 50 mg. of chlorpromazine did impair performance on a driving simulator. Miller (1962) found that after one week of 20 mg. per day, subjects exhibited poorer performance on simulator driving tasks. Trifluoperazine has also been found to have significant negative effect on the driving performance during three low speed vehicle handling tests (Betts et al., 1972). Linnoila (1973) found that thioridazine negatively affected attention skills related to driving but did not affect coordination.

Brandaleone (1963) stated that the tranquilizers of the meprobamate type may affect driving in some patients. According to Wenckstern (1964), 400-600 mg. of meprobamate can lead to decreased driving ability. They can cause dizziness, sleepiness or euphoria in some patients. Smith et al. (1958, as seen in Nichols, 1971) found indications of improved simulator performance among some groups of subjects after administration of benactizine hydrochloride (a meprobamate). Other simulator studies have shown no change in performance after taking meprobamate: Miller and Uhr's (1960) study (as seen in Nichols, 1971); subjects taking 400 mg. (Weatherall, 1959); and subjects taking 800 mg. and 1600 mg. per day (Miller, 1962). Miller (1962) reported slowed reaction times with 12 anxious neurotics, but he also reported decreased anxiety and tension.

Haloperidole (a butyrophenone) reportedly affected the attention of subjects on tasks related to driving but did not affect coordination (Linnoila, 1973). Betts et al. (1972) reported that haloperidole did not affect performance on three low speed vehicle handling tasks.

Other ataractics have also been studied. Diazepam (Vallium) did not affect psychomotor skills related to driving when it was administered the previous evening (Linnoila, 1973). Diazepam in doses of 5 and 10 mg. did not affect those psychomotor tasks when taken just prior to performing them (Linnoila and Mattlia, 1973). Linnoila (1973) stated that diazepam and chlordiazepoxide alone in therapeutic doses did not impair psychomotor skills related to driving. However, Betts et al. (1972) found that chlordiazepoxide did affect performance on three low speed vehicle handling tests.

Sedatives can be divided into two classes: barbiturates and non-barbiturates. Brandaleone (1963), Keilholz and Hobi (1974), and Dokert (1970) writing in the United States, Switzerland and East Germany, respectively, agreed that sedatives (and hypnotics) may produce drowsiness and tiredness and that these drugs may affect driving. Waller (1972) stated that anecdotal evidence showed that some people have traffic problems when they take barbiturates. Wenckstern (1964) reported that barbiturates affect the ability to react and to concentrate and remain in the body a long time (over 12 hours).

An acute dose (100 mg.) of quinalbarbital produced muscle impairment in performance on a driving simulator (Weatherall, 1959). Weatherall also reported that a short acting barbiturate, amobarbital, at doses of 100 mg. impaired performance. Betts (1972) also shows decrement in performance (in three low speed driving tests) of people while under the influence of amobarbital. After six days of 30 mg. of phenobarbital three times a day, Miller (1962) demonstrated some lower reaction time measures on a simulator. Loomis and West (1958, as seen in Nichols, 1971) reported decreased performance on a simulated driving task due to secobarbital. Secobarbital showed a negative effect on other psychomotor tasks related to driving four hours after administration and eight hours later--with sleep intervening.

Non-barbiturate sedatives may also have an effect on driving performance. Perry (1966) cautioned that driving under the influence of chloralhydrate, paraldehyde, glutethimide, and ethchlorvynol may be hazardous. Wenckstern (1964) reported that rauwolfia alkaloids diminsh reaction times and, perhaps, decrease blood pressure which could lead to syncope. In another study, eight hours after administration of flurazepam there was a general decrement in psychomotor performance related to driving (Bixler et al., 1973). Linnoila (1973) found that middle-aged subjects showed impaired performance in the morning after taking nitrazepam the evening before. He also found that ethinamate slightly improved co-ordinative skills but impaired attention (on tasks related to driving) the following morning.

Dokert (1970) reported that people who are taking antidepressants have questionable driving ability. The effect of antidepressants on driving ability has not been investigated much (Keilholz and Hobi, 1974). The effect of the different medications differs considerably and can be divided into these chief categories: the heightening of one's mood--"up", increase of the urge to action and the suppression of anxieties. The chief danger is their potential sleep-inducing effect at the beginning of the treatment. The recommendation is that the ambulatory patient be started with small dosages and that the doctor recommend "no driving" at the beginning of the treatment.

There are differences concerning the licensing of the mentally disturbed whether they are taking medication or not. The Industrial Medical Association (1966) recommended that employees with psychoses or psychoneuroses should be evaluated on an individual basis as to whether they should be allowed to drive commercially or not. Any medication taken must also be considered in its effect upon driving. The IMA also cautioned about patients discharged from hospitals before they are completely well mentally.

Adserballe (1974) reported in Denmark that the driver applicant's mental fitness is judged by the police. They made their judgment based upon a health certificate and other available sources of information. Only those with serious mental disturbances had their condition thoroughly examined prior to receiving a driver's license by the medical examiner, the motor vehicle inspector, or the department of health.

Guidelines for medical advisory boards (U.S. DHEW, 1969) made several recommendations. They felt that most serious cases of impairment will be hospitalized, which results in a temporary suspension of the driving privilege. In some states, the suspension is automatic, without regard to whether the confinement was voluntary or involuntary. However, a patient having enough judgment to seek medical help on his own volition may be as safe a driver as his non-hospitalized peer, regardless of the diagnosis. These cases should be individually considered. In some cases of discharged inpatients, there may be reason to question their future emotional behavior which could affect safe driving. In such cases the HEW guidelines recommended that there should be an observation period of up to one year pending restoration of license. After this period, their personal adjustment will be evaluated and subsequent recommendations of the board can be based on then current function. They believed it was valid to evaluate the driver's license application on the basis of functional ability. The ability to maintain a reasonably stable, realistic, and socially acceptable personality was an important function for safe driving. Individuals with an emotionally erratic pattern, showing periods of irresponsibility, outward or inward aggressiveness, or distorted perceptual thoughts have been identified by accident investigators as potentially high risk groups in motor vehicle accidents.

Koschlig (1974) identified the following from the new medical guidelines adopted in East Germany:

- In general, acute stages of psychoses make the individual unsuitable for driving. Every case should be judged on the type of psychosis and the individual prognosis. Good attributes are: social adjustment, relative freedom from symptoms, and individual's understanding of the disease, high intelligence, and the predominating of depressive tendencies. Negative attributes are: relapse within two years, demonstrated dangerousness or unpredictability, mania, and suicidal tendencies.

- When an individual takes therapeutic drugs and the side effects hinder driving sufficiently, he should not be allowed to drive.

- Only in severe cases of psychopathic personalities is it necessary to restrict the driver's license. Each case must be evaluated individually. An immediate license revocation is required upon hospitalization. Lengthy out-patient treatment falls into the same category. When there is a remission of symptoms, the license can be reinstated.

The Nova Scotia Medical Society (1965) made recommendations for people with personality disorders and psychoneuroses. The psychoneurotic may drive if he has no significant behavioral or drug related problems. The people who have personality disorders represent the biggest problem with regard to safe driving.

The American Medical Association (1968) pointed out that the severe psychotic should be hospitalized and should not be allowed to drive. Generally, other mentally ill people should be evaluated individually; and if they have no significant behavioral problems and no deleterious side effects from drugs, they should not be restricted from driving private vehicles.

The Canadian Medical Association published guidelines (1974) which are in general agreement with the Quebec Ministry of Transport (1973). The CMA recommended the following to physicians:

- Psychopathic Personality

Persons who show a complete disregard for accepted social values, who have a history of violent or irresponsible behavior and who are known to be impulsive with a consequent loss of caution and good judgment, can be a real menace on the road.

- Psychoneuroses

Psychoneurotic applicants require individual evaluation. Each case must be considered on the basis of alertness, social behavior and psychomotor retardation. If no significant behavioral problem exists and if there are no marked side effects from drug therapy, it is usually safe for a person to drive any type of motor vehicle.

- Psychoses

Most persons with a serious psychiatric illness will be hospitalized. Before discharging a patient who has been treated for a psychiatric disability from a public or private hospital, the physician must decide whether the patient is well enough to drive safely when he returns home. The interests of both the patient and the public must play a part in this decision and, in some cases, an observation period at home will be required before the physician can give a sound opinion. A patient discharged from a psychiatric facility may be presumed fit to drive if the hospital or clinic psychiatrist advises the attending physician to this effect. A patient with an acute psychotic illness who is not hospitalized should not drive any type of motor vehicle.

- Repeated Psychotic Illness

A person who has had a number of episodes of psychiatric illness presents an especially difficult problem, particularly when he is applying for a license to drive a passenger transport or heavy commercial vehicle. As a general principle, if the physician feels that it was unsafe for him to drive during any of his past episodes, it is felt that an applicant should be limited to driving a private motor vehicle during periods of remission only.

Patients who have received electro-convulsive therapy (ECT) have impaired mental/motor reflex, as far as the driving act is concerned, and should not be in charge of any motor vehicle until clinical recovery is complete as judged by their psychiatric consultant and family physician.

- Psychiatric Drug Therapy and Driving

The side effects of many drugs commonly used in psychiatric therapy can also produce a definite impairment in patients who might otherwise be quite capable of driving safely. When combined with alcohol these side effects are often greatly intensified.

The Uniform Vehicle Code stated that a person who has been suffering from a mental disability and who has not been restored to competency can be disqualified from having a driver's license. It also stated that when the Commission has good cause to believe that a person with a mental disability cannot operate a motor vehicle safely, this person can be disqualified from having a license. Forty-one states have statutes comparable with these statements (National Committee on Uniform Traffic Laws and Ordinances, 1974 and update to 1975). There were legal precedents suggesting that insanity can be the reason for an "incompetent person" (Words and Phrases, 1965).

4. Sudden Illness, Neurologic and Cerebrovascular Handicaps

Over the years, a large number of studies have discussed the impact of sudden illness or loss of consciousness at the wheel.[1] Their conclusions have been that arteriosclerosis (diagnosed and undiagnosed) has been the predominant cause of these accidents, although occasionally, other neurological or cerebrovascular handicaps have been reported to cause these accidents. All told, the combined impact of these types of impairments is thought to contribute little to the overall traffic safety hazard.

Very little direct evidence was available about the driving performance of persons with either neurological or cerebral vascular diseases. There have been a few case reports describing automobile accidents caused by the following conditions (aneurysms--Keane, 1973; subclavian-steal syndrome--Mozes, 1967;

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[1] Peterson and Petty, 1962; Sommerville, 1962; Hartmann, 1966; Hay, 1968; Grattan and Jeffcoate, 1968; Crancer and McMurracy, 1968; Baker and Spitz, 1970; Waller, 1970; Ysander, 1970; New South Wales DMV, 1971; Hossack, 1974.

Foley, et al., 1969). Occasionally other reports have come from epidemiological studies (Norman, 1960; Herner, et al., 1966; West, et al., 1966). There is, however, an absence of any controlled studies where the effects of these conditions were observed.

Driver education programs reported conflicting data on the successful or unsuccessful education and licensing of persons suffering from neurological diseases or brain damage.[2] In addition, these educational programs did not report follow-up data on the driving performance of their clients.

There was a good deal of opinion regarding the examination and licensing of neurological and cerebrovascular handicaps. The Medical Society of Nova Scotia suggested that patients with inadequate blood flow to the brain, those suffering from syncope, or dizziness should be advised not to operate a motor vehicle. If there has been any cerebral vascular episode causing changes in personality, alertness, ability to make decisions, of if there has been actual loss of motor or sensory power or coordination, these patients should be advised not to operate a motor vehicle. However, if such changes are minimal, they said it may be possible for these individuals to drive private motor vehicles.

Both the Canadian and American Medical Association generally agreed that it would be impossible to cover all the disorders which may produce faintness, syncope and episodic weakness. They stated that it is the pattern of symptoms which must be evaluated in terms of impairment of driving ability. While isolated occurrences are probably of little concern they recommended that persons with histories of multiple occurrences be advised not to drive unless corrective measures can be implemented successfully.

Both Medical associations agreed that the neurological disorders affecting muscular control or coordination and the chronic brain syndromes affecting consciousness, memory, judgment or motor power pose special problems with respect to driving. For such conditions, both groups emphasized that it is functional capacity of the individual which should be evaluated with the physician using his logic and common sense as well as his knowledge of pathological physiology in evaluating the individual client's ability to drive.

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[2] Berner, 1968; Reynolds, 1968; Hofkosh, et al., 1969; Mathias, 1972; Poor, 1972; Long, 1974; Odhner, 1975; Selwyn, 1975; Steensma, 1975; Sullivan, et al., 1975; Ramsey, 1975; Urie, 1975.

The USDHEW Public Health Service guidelines (1969) suggested that for any condition that causes episodic alterations of consciousness the examining physician should recommend licensing as described by the table below.

Table 1. Alterations of Consciousness and Acceptable Levels of Function for Driver Licensure

Group	I Passenger Transport	II Cargo Transport	III Private Auto	IV Periodic Reevaluation	V Limited License
A	yes	yes	yes	yes	no
B	no	no	yes	yes	no
C	no	no	no	yes	yes[a]

[a] i.e., Nocturnal epilepsy and stress hypoglycemia.

This table covers lapses or alteration of consciousness which are from PHS Publication No. 1996 severe enough to cause the person to lose his postural attitude or to be unable to continue whatever action he was involved in. Isolated incidents without likelihood of recurrence should be discounted.

Individuals suffering from one episode of altered consciousness should be grouped as follows:

Group A--Individuals who have not had an episode of altered consciousness for the preceding three years;

Group B--Individuals who have had an episode of altered consciousness in the preceding three years but not within the last year, and

Group C--Individuals who have had an episode of altered consciousness in the preceding year.

They noted that persons suffering from arterial and arterio-venous aneurysms should be considered separately since their symptoms may or may not interfere with driving. Central nervous system aneurysms must be given special evaluation since they present a very high risk. In general, they recommended that such individuals not be recommended for a private vehicle license; certainly not for cargo and transport licenses.

In West Germany, all cerebral disorders were to be evaluated individually Balkanyi (1971). The physician was instructed to investigate the cerebrovascular insult, the possibilities of treatment and then evaluate the remaining functional abilities of the person. In Switzerland (Hartmann, 1971) physican guides emphasized that persons are not allowed to drive if they suffer either from any nervous disorder causing permanent disability or from any condition causing a periodic loss of consciousness.

Waller (1973) summarized that cerebrovascular disorders are likely to impact on driving in three ways:

- Single or episodic loss of consciousness.
- Temporary or permanent paralysis of arms and legs as well as possible changes in vision and hearing.
- Changes in personality judgment or memory.

He felt that most persons will recover sufficiently from these conditions so that, often, several months to a year later they can drive with safety if they have been fully evaluated. He suggested that the examiner pay particular attention to any erratic behavior in the person's life which may be suggestive of altered thought processes. Once these persons resume driving he suggested that they should remain under medical surveillance with the results being sent to the motor vehicle department regularly for several years.

For other chronic or recurring conditions affecting coordination, Waller suggested an annual driving examination by road test. Since episodes of temporary disability occur irregularly, medical examinations were required either yearly or after each episode.

Traumatic head injuries also must be carefully examined to determine if there is any evidence of confusion which could render the person temporarily unable to drive. The Canadian Medical Association (1974) felt that while minor head injuries should not impair driving ability for more than a few hours, a more serious injury resulting in even minimal residual brain damage, must always be fully evaluated for its impact on driving. Some factors that may prohibit driving for an extended period are loss of good judgment, decreased intellectual capacity, post traumatic seizures, visual difficulties and loss of motor power. The Canadian Medical Association suggested as a guide that any head injury patient with post-traumatic amnesis of two to four hours duration, should not drive any motor vehicle for at least three months, and a medical examination should be required before driving is resumed.

In the United States there is legal precedent for the licensing of persons with these handicaps. All but ten states followed the recommendations of the Uniform Motor Vehicle Code and have statutes which stated that the motor vehicle department shall not issue any driver's license to, nor renew the driver's license of any person: a) who has previously been adjudged to be suffering from any mental disability or disease and who has not at the time of application been restored to competence by the methods provided by law; and, b) when the commissioner has good cause to believe that such person, by reason of physical or mental disability, would not be able to operate a motor vehicle with safety upon the highways.

The courts, in considering conditions characterized by sudden attacks which could result in loss of consciousness, have placed particular emphasis on the person's medical history and the relative frequency with which the motorist has suffered attacks in the past. In one case a revoked license was ordered restored to a person who suffered from a mild brain atrophy which had caused a fainting incident while he was driving. The court noted that he had suffered only two previous fainting attacks in his life. They have also considered whether the person is able to predict his moments of disability with advance warning symptoms. Also several license suspensions have been reversed where a person suffering from a spasmodic condition and possibly other neurologic irregularities would, in the opinion of a doctor, always receive enough warning to enable him to stop his car. Also there have been cases where in the court's opinion neurological irregularities have not contributed to a traffic safety hazard because therapeutic medication was capable of controlling these neurological irregularities (American Law Reports, 1971).

There have been cases where the court has ruled that the person would be a traffic safety hazard. One case involved the absence of any competent medical testimony about the existence of two bullets remaining in the patient's head.

There was some information on the education of persons suffering from cerebrovascular and neurological conditions with most programs reporting varying degrees of success. Reynolds (1968) described the difficulty of teaching high school students with brain dysfunction (cerebral palsy) compared to teaching the orthopaedically handicapped or the delicate (hemophelia). The problem was not in the teaching of the "mechanical skills" but, rather, in identifying and compensating for the brain damage or dysfunction which often accompanies cerebral palsy. Brain dysfunction or functional deficts in perceptual and mental processing is often mentioned by persons teaching driving skills to the neurologically impaired (Hofkosh, et al., 1969; Odhner, 1975; Ramsey, 1975; Selwyn, 1975; Sipajlo, 1975; Steensma, 1975; Sullivan, et al., 1975).

With regard to hemiplegic persons in particular, there was some discussion in the literature about patterns of perceptual and motor performance of right hemiplegia (left hemisphere brain damage) and left hemiplegia (right hemisphere brain damage). (Bardach, 1969; Long, 1974; Sullivan, et al., 1974). Hofkosh, Sipajlo, and Brody (1969) suggested that, in patients with moderate brain damage, left hemiplegics demonstrate subtle to obvious perception or spatial relations difficulties more often than do right hemiplegics. Other authors agreed but with qualifications (Diller and Weinburg, 1968; Sullivan, et al., 1975; Ramsey, 1975). Studying hemiplegics, Diller and Weinberg found the pattern of performance deficits for both visual and auditory tasks to vary, they hypothesized, with the usage of either short or long-term memory. Diller (1969) stated that, while brain damage always occurs in hemiplegia, behavioral functioning is not always adversely affected. He felt that those who demonstrate "organic" traits will be more likely to have more severe perceptual, cognitive and emotional problems. All authors agreed that each case must be evaluated individually.

Bardach (1971) examined the psychological factors associated with the education of 31 patients rated as "difficult" by their driving instructors. For the brain-damaged patients she noted that perceptual-motor and cognitive problems occurred more often than body image or emotional problems. Left hemiplegics seemed to demonstrate cognitive difficulties in inadequate visual scanning and in an inability to shift with the changing demands of the driving task (distractibility or confusion). The right hemiplegics did not appear to demonstrate impairments functionally related to the driving task. Some driver education programs report teaching visual scanning procedures which appear to compensate for the loss of visual field due to brain damage.

The greatest difficulty as Reynolds (1968) noted, was the early diagnosis of these perceptual or visual problems. Sipajlo (1969) described several behind-the-wheel maneuvers which brain-damaged persons without compensatory training have difficulty completing. These included driving in clockwise and counterclockwise circle patterns. These circles were followed by figure-eight maneuvers which seem to be useful in the evaluation of driver planning, perception and coordination. The figure-eight maneuver was reported by several other handicap driver education programs (Odhner, 1975; Ramsey, 1975, Sullivan, et al., 1974). Sullivan has described in detail a test battery which was created to evaluate the brain-damaged person's readiness to drive. The test takes one hour and can be administered by a qualified occupational or physical therapist after a short training period. The test consisted of six separate evaluations: physical considerations, perceptual tests, language tests, visual tests, reaction time and general attitude and behavior. Test results for 88 clients showed a high correlation with a behind-the-wheel evaluation administered by the institution's driving instructor.

5. Epilepsy

According to the Epilepsy Foundation (as seen in Arthur D. Little, 1970), more attention has been paid to the licensing of epileptics than to the licensing of persons with any other disease including alcoholism. Unfortunately most studies of epileptic driving behavior do not differentiate between different forms of epilepsy.

There are several types (Waller, 1967; Northcroft). Grand mal epilepsy is both the most prevalent and the most incapacitating. In this condition, the person loses consciousness and has convulsions. For some individuals, the seizure may be preceded by a warning sensation or aura. Another type is petit mal epilepsy which is distinguished by frequent brief losses of consciousness without convulsions. This condition is rarely associated with an aura. Focal or Jacksonian attacks are characterized by convulsions starting in or limited to one area of the body (e.g., a leg or hand). Such a seizure may progress to involve the entire body. Psychomotor seizures involve the temporal lobe of the brain and are frequently associated with personality changes. The attack may appear as a brief attack of insanity or a brief trance. Sometimes grand mal convulsions also occur. Finally, there is a variety of less prevalent types of seizures (including myoclonic, drop and hypothalamic epilepsy).

Hierons, in 1965, cited a number of individual cases in England where epileptics have caused traffic accidents. This opinion was supported by Cheetham (1972) who stated that uncontrolled grand mal or petit mal epileptics were likely to be involved in more than one accident and that an attack might occur at any time.

A few more rigorous studies have been reported. In one study of 42,255 reported road accidents (Hermer, et al., 1966) in Sweden from 1959-1963, 41 accidents were caused by sudden illness of the driver. Of these 41, 10 were due to epilepsy--or one for every 4,000 accidents. Davis (1972, as seen in Epilepsy Foundation of American, 1975) studied the driving records of 77 Oklahoma licensed epileptics. He found that the male epileptics had accident rates three times higher than all other licensed drivers. The females also had higher accident rates but lower violation rates. Exercising some statistical control in their study, Crancer and McMurray (1968) studied the accident and violation rates of 39,242 Washington State medically restricted drivers. The group of epileptic drivers had statistically higher accident and violation rates than all Washington's 1.6 million licensed drivers. In California, Waller (1965) compared epileptic drivers with a statistically weighted control group of normal drivers. The epileptics had twice the number of accidents per million miles and 1.4 times the number of violations.

Waller (1967) studied the accident and violation rate of epileptic drivers whose seizures were less serious (always occurred at night, were always preceded by an aura or were always petit mal). Their driving performance was compared to epileptic drivers whose seizures were more serious. Although there was a trend toward fewer accidents among drivers who had nocturnal seizures, auras, or petit mal seizures, the samples were small and the differences were not statistically significant. In contrast to studies finding epileptics having higher violation rates, Ritter and Ritzel (1972), in West Germany, found that the 546 epileptics they studied had fewer traffic violations than the general public.

According to the Epilepsy Foundation of America (1975) the medication used by epileptics may cause sedation and by itself could be the cause of accidents. Dokert (1970, East Germany) was of the opinion that antiepileptic drugs hindered driving somewhat. He felt this negative effect was increased with the use of alcohol. In a survey of 100 patients whose epilepsy was a drug resistant temporal-lobe type who had an anterior temporal lobectomy three to ten years previously, Falconer and Taylor, (1967) found that 13 of the patients were driving motor vehicles; and in their opinion, 26 others could reasonably apply for licenses.

There were many differing opinions regarding the licensing of epileptics. A survey in Great Britain (Phemister, 1961) found a significant number of individuals (28 or 130 surveyed), with and without licenses, who were driving and liable for recurrent attacks. These people drove despite warnings from their doctors.

Imrie's (1972) opinion was that people who have epilepsy should only be allowed to drive if their physicians felt that they were unlikely to have a seizure. He felt that it was not justified to license an epileptic simply becuase he had been free from a seizure for two or three years. In a British article, Espir (1967) stated that only one year conditional licenses for private vehicles should be granted and then renewed only after medical reassessment. In these cases, the applicant must provide a written statement that his prescribed treatment will be followed regularly and with the understanding that driving will not be permitted if the agreed treatment was discontinued, if medication was omitted, or if another seizure occurred. In Austria, Sluga (1968) concluded that an individual who was seizure free for 1.3 years without medication (five years with medication), could demonstrate a normal EEG, and passed a psychiatric examination or psychological personality profile should be allowed to drive.

Balkanyi (1971) suggested that licenses be granted two years after the last seizure. Ransford (1972) disagreed and stated that the two-year period was too severe. Kuhl and his associates (1967) disagreed also. In follow-up studies of 173 patients, who had the onset of epilepsy after the age of 17 and history of seizures not exceeding five years, they concluded that the very strict rules for the licensing of epileptics are inappropriate. They recommended that in certain cases of epilepsy (those well under control, those with a good medical prognosis, and in cases of epilepsy with adult onset), a period of three months without seizures was sufficient for private licensing. For commercial licensing, they suggested stricter medical control and license renewal after one, two and five years.

The Epilepsy Foundation of America (1975) suggested, after a review of the literature on epilepsy and driving, that epileptics be evaluated on an individual basis. They felt that licenses should be allowed upon the examining physician's statement that the driver was under medication and free from seizures. Further, temporary licenses should be permitted for three to six months with permanent licensure after two seizure-free years. The American Medical Association's (1968) physician's guide recommended that epileptics could drive private motor vehicles after one seizure-free year if they reliably took their medication. They recommended that epileptics should not drive commercial or passenger transport vehicles. Also each individual, regardless of his prognosis, should be medically re-evaluated every six months. The Canadian Medical Association's (1974) guide for physicians recommended that an epileptic: 1) who had been free from seizures for two years; 2) who was conscientious in taking his medication; 3) who did not have medication side effects which impair driving; and 4) who was under medical supervision could usually operate a motor vehicle safely. However, an epileptic should not drive a passenger transport or heavy commercial vehicle.

Table 2 summarizes the recommendation to medical advisory boards for alterations of consciousness, which included epilepsy (U.S.D.H.E.W., 1969). Group A are individuals who have not had an episode of altered consciousness for the preceding three years. Group B are people who have had an episode of altered consciousness in the preceding three years but not within the last year. Group C are those who have had an episode of altered consciousness in the preceding year.

Table 2. Alterations of Consciousness and Acceptable Levels of Function for Driver Licensure

Group	I Passenger Transport	II Cargo Transport	III Private Auto	IV Periodic Reevaluation	V Limited License
A	yes	yes	yes	yes	no
B	no	no	yes	yes	no
C	no	no	no	yes	yes[a]

[a] i.e., Nocturnal epilepsy and stress hypoglycemia.

According to Arthur D. Little (1970), in most countries that required a driver's license, even the possibility of an epileptic seizure disqualified an individual from driving. However, a large proportion of epileptics drive anyway. Ritter and Ritzel (1972) noted that Eastern European countries have strict regulations concerning epileptics while Scandinavian countries tend to issue licenses to epileptics because they felt that epileptics would drive even if they are not licensed. In contrast, Denmark (Adserballe, 1974) did not allow epileptics to drive. In East Germany, the new medical guidelines required two years free from seizure, no signs of unsuitability for driving (medication incapacities, vision or coordination problems, etc.), and yearly physicals including EEG's. Epileptics were not allowed to drive commercial vehicles (Koschlig, 1974).

Before the Vehicle and Driver Licenses Act of 1969 in England, a person admitting to ever having epilepsy was not allowed to drive (Raffle, 1971). This new law stated that a license applicant who is an epileptic must satisfy these conditions:

> ". he shall have been free from any epileptic attack whilst awake for at least three years from the date when the license is to have effect;
>
> . in the case of an applicant who has had such attacks whilst asleep during that period he shall have been subject to such attacks since before the beginning of that period;
>
> . the driving of a vehicle by him in pursuance of the license is not likely to be a source of danger to the public."

According to the Quebec Ministry of Transport (1973):

> "Persons who, although suffering from a type of epilepsy and whether they take medication or not, have not had an attack for more than two years, may usually drive a private vehicle whose maximum curb weight does not exceed 6,000 pounds, as long as the medication they take had no undesirable side effects which might impair their capacity to drive."

Manus and Less (1972) in studying the licensing practices of the states noted a trend toward conditional or restricted licenses for persons affected by unstable, chronic medical conditions.

Seventeen states have laws which prohibited certain epileptics from being licensed to drive (National Committee on Uniform Traffic Laws and Ordinances, 1975). These states' restrictions ranged from not allowing an epileptic to drive at all to restricted priviledges. Usually a physician's statement is required certifying that the person was under medication and free from seizures or under medical supervision with two seizure-free years prior to the licensing.

There were several legal precedents concerning epileptics licensing (American Law Reports, 1975). In one case (1942) the court stated that there was common agreement that an epileptic person would be considered incompetent or unable to exercise reasonable and ordinary control over a vehicle. This statute allowed administrative suspension of an epileptic's license. In another case (1956), an epileptic's license was not renewed when it was ascertained that he had one seizure within the prior two years. He was required to submit proof of two years of seizure freedom without use of medication. There was also precedent from two cases (1962, 1965) where failure to take prescribed medication (thereby increasing the potential of having a seizure) was supportive to upholding license suspension.

In 1970 an individual whose license had not been restored by an administrative licensing board, was granted restoration of his license by the court. Even though he had a 20-year history of epilepsy with at least seven seizures, his accident free three-year driving record (75,000 miles) and the controllability of his disease by medication was sufficient evidence for restoration of driving privileges. In 1954, a mild epileptic had his license restored by the court because he had warning prior to his seizures, had suffered only three seizures in 11 years, and because he had supportive medical testimony that he could be a safe driver if he continued his medication.

There was almost no information specifically concerning the epileptic and driver education. Kirk (1972) stated that the need for special classes and schools for epileptics was disappearing. The major reason for these special classes was the problem of handling convulsions during the class. Modern medication had now made epilepsy more controllable. Glenn (1975) had identified one complication. By state law in Ohio, epileptics must have insurance before they take driving lessons and must file a medical report every couple of months.

6. Diabetes

Diabetes (American Diabetes Association, 1966) is a medical condition in which the body cannot utilize and properly store glucose. In uncontrollable diabetes, diabetic coma and/or death is possible. Diabetes often can be controlled

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by proper diet and/or insulin or other drugs. When insulin treatment is necessary the problem of insulin reaction may occur. A reaction can cause symptoms ranging from lightheadedness to loss of consciousness.

Emara (1969) performed a survey for an Egyptian transportation company. His conclusion, based on 100 employed diabetics, was that there was not a significant incidence of motor car or bus accidents. In Washington, D.C. (Washington, D.C. Department of Motor Vehicles, 1973) a random selection of traffic records for 150 diabetics (out of 1,153 diabetic drivers) were compared to all D.C. drivers. Diabetics who were under adequate medical management had better and safer driving records. Herner, et al., (1966), reporting on an area of Sweden, found only three incidences of accidents caused by diabetics with hypoglycemia. This was out of a total 42,255 road accidents investigated by police in 1959-1963.

In a well controlled study comparing 256 diabetic drivers with normal drivers in Sweden, diabetics had only 51% as many accidents and 69% as many accidents combined with serious traffic offenses (Ysander, 1966). Later, Ysander (1970) reported comparing 219 drivers with diabetes who were not required to have regular medical examinations to a control group (matched for age, sex, driving license period, and exposure). Twenty-one percent of the diabetic drivers did not drive at all because of the disease or its complications. Over a 10-year period (1955-1964) for those who did drive, no accidents or traffic violations occurred as a result of the diabetes or its treatment. Also, there were fewer accidents right after the beginning of the illness than there were for the total 10-year period for the diabetics. He concluded that diabetics did not constitute an increase in traffic risk. He suggested that the awareness of the disease may be a good prophylactic factor from a traffic safety point of view.

In a somewhat controlled study of 346 diabetic drivers on Prince Edward Island, Canada (Campbell and Ellis, 1969), diabetics had 1.7 as many accidents and many more convictions than age-matched non-diabetic controls. Also, there were three times as many accidents and major conviction repeaters among diabetics. In another somewhat controlled study (Crancer and McMurray, 1968), over 39,000 Washington State medically restricted drivers were compared with the State's 1.6 million licensed drivers. The diabetics had both higher accident and violation rates. Waller's (1965) study of 2,160 persons with chronic medical conditions, compared with 926 other California drivers, indicated that diabetics had 78% more accidents and 39% more violations per million miles than the age-adjusted control group.

Imrie's (1962) opinion was that diabetics are a risk only if they take insulin. With insulin takers, there was a problem of hypoglycemia and loss of

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consciousness. If a patient was subject to hypoglycemic attacks, it was better if he did not drive. Brandaleone (1963) generally agreed. If a diabetic on insulin had frequent insulin reactions, he should not drive. In East Germany, Dokert (1970) suggested that if the diabetic is under control with insulin or anti-diabetic drugs, then he should be allowed to drive. Campbell and Ellis (1969) found in their study that the type of insulin therapy did not seem to bear any significance to the involvement of diabetics in any particular types of accidents, although their accidents and violation rates were higher than normal.

Waller (1973) felt that diabetics should not be allowed to drive for 18 to 24 months after their last insulin reaction. He also stated that complications such as arteriosclerosis and visual changes should prevent them from driving unless the associated conditions are mild. The American Medical Association (1968) and the Nova Scotia Medical Society (1966) thought that a medical examination should be required if a license applicant has diabetes and takes insulin and had not been medically evaluated during the past year. The AMA went further in its physicians' guide (1968) to say that a diabetic controlled by diet and a sulfonylurea drug, may drive any motor vehicle. Persons on insulin could drive private but not commercial vehicles, and the uncontrolled diabetic should not drive at all. Raffle's (1971) opinion was that diabetics controlled by diet and oral hypoglycemic agents had a small risk of prolonged hypoglycemia, and they should probably not be allowed to drive buses or vehicles that carry heavy goods. Also, those who took insulin and drove with symptoms of hypoglycemia could be charged with driving under the influence of drugs. The Canadian Medical Association (1974) agreed that the diabetics controlled by diet or diet and oral medication could drive any type of motor vehicle safely if they were under regular medical supervision. They also said that those who required insulin but who were under good control and were not subject to hypoglycemia reactions could drive private and light commercial vehicles.

For drivers who developed hypoglycemic reactions they suggested no driving until this complication was under control for at least a month. They should then remain under close medical supervision.

Table 3 summarizes the recommendation to medical advisory boards for alterations of consciousness, which included diabetic hypoglycemia (U.S. D.H.E.W., 1969).

Table 3. Alterations of Consciousness and Acceptable Levels of Function for Driver Licensure

Group	I Passenger Transport	II Cargo Transport	III Private Auto	IV Periodic Reevaluation	V Limited License
A	yes	yes	yes	yes	no
B	no	no	yes	yes	no
C	no	no	no	yes	yes[a]

[a] i.e., Nocturnal epilepsy and stress hypoglycemia.

Group A are individuals who have not had an episode of altered consciousness for the preceding three years. Group B are people who have had an episode of altered consciousness in the preceding three years but not within the last year. Group C are those who have had an episode of altered consciousness in the preceding year.

Less and Manus (1972) reported that the trend in the U.S. was to license applicants with stable diabetes while restricting drivers who are unstable. A number of states required diabetic drivers to submit regular medical reports--Washington, D.C., Maryland, North Carolina, and Pennsylvania, for example (Washington, D.C. Department of Motor Vehicles, 1973).

There were also two legal precedents (American Law Reports, updated to 1975) for restoring licenses to diabetics whose diseases were relatively controlled and who had warning symptoms prior to insulin reactions. However, if an individual was subject and likely to lose consciousness from a medical condition, he might be charged with negligence (Corpus Juris Secundum, 1975).

7. Narcolepsy

Most narcoleptics go undiagnosed; it is a fairly common disorder (Yoss and Daly, 1963). Waller (1973) disputed this. Yoss and Daly described the narcoleptic tetrad: 1) excessive sleepiness (narcolepsy proper), 2) cataplexy--muscular weakness induced by emotion, 3) sleep paralysis or attacks of transient inability to move in the stage between arousal and sleep, 4) hypnagogic hallucinations--during drowsy state. They found that 25% of their large number of patients had symptom 1; 64% had 2; 28% had 3; 30% had 4; and only 14% had all symptoms. There was an effective drug treatment that usually kept the condition under control. In questioning 100 narcoleptic drivers Yoss and Daly found:

- Ninety-eight admitted episodes of drowsiness or actual sleep while driving.

- Fourteen admitted one to six accidents as a direct result of falling alseep.

- Seventeen came close to serious accidents when they fell asleep and ran off the road.

- Many pulled to the side of the road and slept or walked around to wake up.

Since there is drug treatment that usually keeps the condition under control, they concluded that narcoleptics could drive when their treatment is effective. If the patient stops treatment, they recommended that he should stop driving for two years and resume driving, if there were no more symptoms.

Bartels and Kusakcioglu (1965) compared 115 driving narcoleptic patients with a normal group (105) matched for sex and age. They found:

- Seventy-seven percent of the narcoleptics suffered from undue drowsiness while driving and only 14% of the normals admitted drowsiness.

- Forty-two percent of the narcoleptics had fallen asleep while driving as compared to 7% of the normals.

- Only 0.9% of the normals had an accident as a result of falling asleep while driving, while 17% of the narcoleptics had.

- Fifty percent of the narcoleptics avoid driving.

Yoss (1969) reported that he had developed a test to measure the five stages of wakefulness. His ten-minute test was based upon studying the pupils' diameter and eyelid behavior in over 200 persons. The test has been able to discriminate between acknowledged unsafe sleepy drivers and safe drivers.

In regard to licensing, Ransford (1972) reported that more research was needed on narcolepsy before licensing guidelines could be made; Balkanyi (1971, West Germany) stated that it was difficult to diagnose a narcoleptic. Waller (1973) felt that a narcoleptic should have his license restricted along guidelines similar to those used for epilepsy.

The narcoleptic could drive if he has not had an attack for more than two years, whether he was taking medicine or not. If he is taking medicine, no undesirable side effects are allowed (Nova Scotia Medical Society, 1965; Quebec Ministry of Transport, 1973). According to the Canadian Medical Association (1974), narcoleptics should not drive until they are free from attacks for three months and are experiencing no side effects. They then can drive only private vehicles. The new medical guidelines from East Germany (Koschlig, 1974) recommended that the narcoleptic can drive a private vehicle if the disease has been successfully treated and no medicine is necessary. However, EEG examinations have to be made every six months.

Table 4 summarizes the recommendation to medical advisory boards for alterations of consciousness, which would include narcolepsy (USDHEW, 1969).

Table 4. Alterations of Consciousness and Acceptable Levels of Function for Driver Licensure

Group	I Passenger Transport	II Cargo Transport	III Private Auto	IV Periodic Reevaluation	V Limited License
A	yes	yes	yes	yes	no
B	no	no	yes	yes	no
C	no	no	no	yes	yes[a]

[a] i.e., Nocturnal epilepsy and stress hypoglycemia.

Group A are individuals who have not had an episode of altered consciousness for the preceding three years. Group B are people who have had an episode of altered consciousness in the preceding three years but not within the last year. Group C are those who have had an episode of altered consciousness in the preceding year.

There were legal precedents that may make a driver who falls asleep at the wheel guilty of negligence or even gross negligence (Corpus Juris Secundum updated to 1975). He would be considered negligent either in allowing himself to fall asleep or in continuing to drive while in danger of falling asleep.

8. Vertigo

There were only four reported cases of patients with vertigo being involved in accidents caused by this condition. Norman (1960) stated that in the

London Transport for 220,000 bus driver years, there were two cases of laryngeal vertigo in which the drivers became unconscious and were involved in an accident. Mozes (1967) reported two cases of automobile drivers causing accidents who had subclavian steal syndreme which produced true vertigo.

There were several expert opinions on vertigo and licensing. Imrie (1962) stated that people who suffer from labyrinth impairments with attacks of vertigo and blackouts should not drive. Hartmann (1971) reported that the new Swiss regulation recommended no driving for people who have serious diseases of the inner or middle ear. People with Meniere's syndrome who suffer from vertigo without warning should not drive until treatment has controlled such attacks (Nova Scotia Medical Society, 1965; American Medical Association, 1968; Canadian Medical Association, 1974). Further, individuals with any acute labyrinthitis or positional vertigo should be advised not to drive any type of vehicle until their condition has subsided or responded to treatment (Canadian Medical Association, 1974).

9. Cardiovascular and Circulatory Diseases

There are many types of diseases related to the heart and the circulatory system. The literature concerned with driving behavior and driver licensing was not consistent in its treatment of these diseases. The literature considered such diagnostic categories as arteriosclerosis, hypertension, cardiac arrhythmias, congestive heart failure, congenital heart disease, Raynaud's phenomenon, and others (Waller, 1973). Heart and circulatory problems become more prevalent with increased age presenting an added concern for people in the traffic safety field (American Medical Association, 1974).

Baroody (1970) mentioned several conditions which can affect the driving of patients with cardiac problems. Exposure to cold can induce angina in some patients with coronary atherosclerosis and coronary insufficiency. Patients with Raynaud's phenomenon may develop blanching and cyanosis of the hands and fingers. An excessively hot environment can also cause increased stress or difficulty in body temperature regulation for people with cardiovascular disease. Simply a sudden turning of the head and neck can affect the carotid or vertebrobasilar systems and may cause vertigo. Mild pre-existing vertigo can be aggravated by sudden distortion of the visual image--such as windshield distortion. Patients with Stokes-Adams syndrome, borderline congestive heart failure, and severe disease involving the vasila carotid artery systems should exercise caution in driving since they are susceptible to alterations of consciousness.

Brandaleone (1963) recommended that people with aortic stenosis, congestive heart failure, carotid sinus syndrome, Stokes-Adams syndrome, or any other cardiac condition which might suddenly incapacitate them should not drive. Cheetham (1974), reporting in South Africa, stated that certain individuals are more likely to be involved in accidents. They are those who are likely to have a heart attack at any time without warning, especially under duress and fatigue or those who suffer from severe hypertension and who have a great deal of internalized hostility and aggression.

Several articles have reported studies of the cardiac stress under various driving conditions. Hoffman (1963), in Germany, reported that, in general, data suggested that a myocardial infarction can be provoked by the stress connected with the operation of a vehicle if the coronary arteries have suffered previous damage. This could cause accidents. To verify this, Hoffman (1963) analyzed the blood circulation changes in different traffic situations by means of a telemetric system. He compared the data for 400 healthy drivers to the data for 26 drivers with manifest coronary insufficiency. No differences were found in pulse frequencies but significant differences were found in EKG and blood pressure. He concluded that at least for drivers suffering from angina pectoris driving a vehicle is a safety risk. Hoffman (1966) verified this in another study where he found similar results. In subjects with clearly documented heart disease, Bellet et al. (1968) found significant electrocardiographic changes while driving. These were: ischemic S-T depression, multifocal premature contractions, and ventricular bigeminal or trigeminal rhythm. Normal subjects, except for a variable increase in heart rate, had no significant changes.

Little et al. (1973) found results which contradicted the previous studies. They studied, continuously, five normotensive subjects, five hypertensive subjects, and five people with angina pectoris, who were either hypertensive or normotensive for 24 hours. Observations were made of direct arterial pressure and electrograms during 30 separate driving episodes. In all but one subject, apart from variable changes in the heart rate, no significant arrhythmias or S-T segment changes were observed. The arterial pressure remained relatively stable for all persons, and there was no significant difference between levels of blood pressure at the beginning and end of a journey. There were short periods of raised arterial pressure during driving related to episodes such as overtaking, but these quickly returned to baseline levels. Kellerman et al. (1971) generally supported these data in their research. They found coronary patients were capable of energy expenditures at over twice the levels calculated as being needed for motor vehicle driving in the city during peak traffic.

Ysander (1970) concluded that sudden illness while driving has been proven to play a minor role in traffic accidents. In investigations taking into account the causes of sudden illness, cardiovascular diseases predominate. He cautioned on comparison between studies: the research samples are usually heterogeneous; the studies do not have adequate control groups; evaluation of results of studies from different countries were not comparable because they have different health requirements for licensing. In support of Ysander's major point concerning the prevalence of sudden cardiovascular illness causing accidents, Herner et al. (1966) found only 10 of 42,255 road accidents to be caused by cardiovascular problems (myocardial infarction--7; arteriosclerotic or rheumatic heart disease with Stokes-Adams syndrome--3).

Ysander (1966) studied 612 drivers with chronic diseases in Sweden. He found that those with cardiovascular disease had many fewer accidents than the normal control group. In Washington, D. C., it was found that drivers with coronary heart disease had better driving records than average. The hypertension group had poorer records (Washington, D. C. Department of Motor Vehicles, 1973). Crancer and McMurrary (1968), in the State of Washington, found that persons with heart disease had slightly higher accident rates (but not statistically significant), when compared to the unrestricted driving population in the state. The heart group did have fewer violations. In studying the driving records of drivers with cardiovascular disease, Crancer and Quiring (1968) matched them for sex and age with a control group. The heart group had a higher violation rate but an accident rate equal to the normal driver. Waller's 1965 study in California reported the drivers with cardiovascular disease as having 1.6 times the number of accidents and 1.3 times the number of violations than expected.

On the basis of medical records of 600 persons with circulatory illness, Hartmann (1965), in Switzerland, came to the following conclusions:

- Coronary heart valve defects and heart deformities--for people who have mitral or aorta valve defects there is an increased possibility of circulatory insufficiency or acute heart crisis. In the study these people drove as well as normal drivers.

- Angina pectoris and infarcts--for these persons there is a possibility of seizure or acute heart syncope. Information was inconclusive about their driving ability.

- Vascular disease--the driving performance was good for those with slightly elevated blood pressure.

- Arteriosclerosis--this can cause various conditions which affect driving ability.

- Circulatory insufficiency--for those who also have a deterioration of general health, there can be difficulty in driving.

Crancer and O'Neall (1970) randomly selected groups of drivers with arteriosclerosis, hypertension, rheumatic heart disease, and other heart diseases and compared them to non-restricted drivers matched for age, sex, and city of residence. The arteriosclerotic and the hypertensive disease groups were found to have significantly higher accident rates than non-restricted drivers. The rheumatic and other heart disease groups had the same number of accidents as the non-restricted group. The violation rates for all groups were comparable.

A number of studies were based on autopsies of drivers who die at the wheel. Of 225 single motor vehicle fatalities in an Ohio county, 57 were classified by autopsy as natural deaths (Gerber et al. 1962). Fifty-three of the 57 died of cardiovascular disease (43 were due to myocardial infarction). Peterson and Petty (1962) reported on the autopsies of 237 driver fatalities for all causes in Maryland. Eighty-one drivers died of natural causes; of these 81, 36 were involved in accidents. Ninety-nine percent of all natural deaths were due to cardiovascular disease. About 50% of these drivers had known that they had symptoms prior to their deaths. Hartmann (1966) reported that of 86 cases of death at the wheel, 80 were due to heart failure. Coronary sclerotic heart disease was the most frequent cause of death. In a study (West et al., 1968) of 1,026 drivers who died within 15 minutes of their accidents in California, 15% died of natural causes at the wheel. Of these 155 drivers. 94% died of heart disease--the primary cause was arteriosclerosis (86%), with rheumatic heart disease accounting for 5%. Baker and Spitz (1970) found in an investigation of 591 collisions involving fatalities to drivers or pedestrians that none of the collisions were related to natural causes. Post-mortems were performed on 102 driver deaths in Australia (Hassack, 1974). Eleven died of natural causes, and all were related to heart problems. In five cases, the drivers were able to stop the car and avoid being in an accident before they died. In the others, only one case resulted in an accident with another vehicle.

Of 47 drivers dying of natural causes at the wheel, 87% died of heart disease (DiMaio, 1969). This was due primarily to occlusive coronary arteriosclerosis. Twenty of these drivers knew they had heart disease. In Sweden (1967), Voight reported that most people dying of natural causes while driving died of arteriosclerotic cardiac heart disease. In a study of 1,348 instances of death due to coronary heart disease for people under 65 years of age, Myerberg and Davis (1964) found that 71 died while driving.

There are studies which discuss the problems associated with pacemakers and driving. Edhag (1969) found that of 52 pacemaker patients with driver licenses, 26 drove a car, and 14 of these drove at least five times a week. Three needed a driver's license to pursue their occupations. Of those not driving, several had been recommended not to drive by a physician. No patients reported accidents associated with the pacemaker. Sowton (1972) reported that of 516 individuals with pacemakers in Great Britain, 39 drove. Of these 39, only one reported an accident; and this accident was unrelated to the pacemaker. None of the 516 persons reported suffering from sudden attacks of giddiness or fainting. Heinz et al. (1969), in the study of the driving behavior of 27 cardiac pacemaker patients, found that they decreased their driving exposure 36% after pacemaker installation. In this German study, the patients reported five minor accidents in the year following implantation. There were also some problems associated with electromagnetic interferences with the pacemakers due to certain auto ignition systems. Crancer and O'Neall (1970) compared 44 licensed pacemaker drivers with two matched groups of drivers, one group with heart disease and one group of non-restricted drivers. They found no significant difference between the groups for either accidents or violations.

Raffle (1971) reported that people with cardiac pacemakers should be allowed to drive but should not be permitted to drive a vehicle with heavy goods or for public service. Ransford (1972) said that people with pacemakers can drive one month after their operation if they are seeing a physician once every three months. The Driver Licensing Guidelines for Medical Advisory Board (USDHEW, 1969) and the Canadian Medical Association (1974) were in general agreement with Ransford.

Sowton (1972) reported on the licensing practices for people with cardiac pacemakers. In England, Wales and Scotland there was confusion with different licensing authorities adopting different views. Some patients have their licenses revoked and some were allowed to drive. In the English guidelines reported by Raffle (1971), pacemaker patients, as the pacemakers become more reliable, will be allowed to drive private vehicles. The licensing situation in the U.S. differed from state to state; generally there was no objection to driving with a pacemaker as long as the physician's certificate said the pacemaker functions normally, and the patient continued under medical supervision (Sowton, 1972). In Australia, Hungary, Ireland, Japan, West Germany, East Germany, Poland, Belgium, Holland and France, pacemaker patients were allowed to drive private vehicles as long as they receive support from their physicians. They were usually not allowed to drive commercial vehicles.

Individuals with pacemakers should not drive cargo or passenger transport vehicles (USDHEW, 1969). Brandaleone (1974) reported that the Industrial

Medical Association believed that a person with a pacemaker should not be permitted to drive a commercial vehicle; however, civilian drivers with pacemakers should be evaluated individually.

While the non-professional driver had the choice of not driving when he does not feel well, professional drivers (taxi, truck, bus, etc.) usually did not have this choice; therefore, persons with cardiac problems should not be licensed as professional drivers (Hartmann, 1965). Raffle (1958) reported that 26% of all bus drivers released from further work in a London bus company for medical reasons were rejected because of cardiovascular disorders. Levey et al. (1963) reported an accident caused by the heart attack of a bus driver who had previously had an attack but who appeared to have recovered. Trapnell and Goff (1963) reported that five out of 35 commercial drivers who had one heart attack had additional heart attacks, but none caused accidents. Norman (1960) reported that during 1949-1959 the London Transport employed an average of 20,000 drivers per year. During this time, there were 14 cases where drivers lost consciousness due to coronary infarction.

There was not much information concerning the effect of drugs used with coronary and circulatory diseases and driving behavior. Brandaleone's (1958) opinion was that antihypertensive drugs can be dangerous to driving because of their sedative and hypotensive effects. Dokert (1970) reported that anticoagulants seemed to have no effect on driving. Baroody (1970) reported that drugs used for the control of heart disease could be a problem.

There were several personal opinions and committee recommendations for licensing of persons with cardiovascular disease. Somerville (1962) presented his opinion: persons suffering from fainting attacks, especially Stokes-Adams attacks, fainting from vaso-vagal attacks, aortic stenosis, and carotid sinus sensitivity should not be allowed to drive. In uncomplicated cases of angina or coronary thrombosis, persons should be allowed to drive private vehicles.

Imrie (1962) made the following recommendations for not allowing driving in cardiac cases when:

- There was doubt of fitness to drive.
- Electrocardiographic changes persisted after infarction.
- There was recurring angina pectoris.
- There was aortic regurgitation.

- There was aortic stenosis.

- Hypertension was complicated by other conditions.

Balkanyi (1971) reported an expert's viewpoint from West Germany. People with carotid sinus hypotention could drive but they should use side mirrors. Severe hypertension was a problem in driving because of the potential for syncope. People with angina could drive since they generally have time to prevent accidents if they have an acute heart attack.

Ransford (1972) presented another opinion from Canada. He reported that congenital heart defects were a problem in driving if there are resultant performance deficiencies. People who have mild or infrequent angina could be allowed to drive. If a person has angina at rest or if it was provoked by the effort required to maneuver a vehicle, he should not be licensed. Hypertension was only a problem if there were complications.

There were a number of guides to the licensing of people with cardiovascular and circulatory handicaps (Nova Scotia Medical Society, 1965; USDHEW, 1969: American Medical Association, 1959; Raffle, 1971; Quebec Ministry of Transport, 1973; Canadian Medical Association). They represented considerable attempts to suggest the appropriateness of licensing of an individual with a very complex disease. Because of the technical content of these guides, abstracting them might prevent the communication of much relevant information. As a necessity, therefore, the pertinent sections of four guides are presented in Appendix A.

Hartmann (1965 and 1971) reported that the new guidelines in Switzerland excluded from driving only those with severe cardiac problems, serious vascular problems and severe blood pressure problems. The Industrial Medical Association (1966) made the point that in evaluating a person for commercial driving, it was necessary also to consider whether he was capable of doing the work associated with his driving.

The Uniform Vehicle Code stated that a person who has been suffering from a physical disability and who has not been restored to competency may be disqualified from having a driver's license. It also stated that when the commission had good cause to believe that a person with a physical disability could not operate a motor vehicle safely, this person could be disqualified from having a license. Forty-one states have statutes comparable with these statements (National Committee on Uniform Traffic Laws and Ordinances, 1974 and updated to 1975).

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There was a legal precedent concerning cardiovascular disease and driving (American Law Reports, 1971). In a 1955 case, the suspension of a woman's license was sustained; she suffered from arteriosclerosis and hypertension as well as a stroke which left her left leg and arm partly paralyzed. Public safety prevailed over her private right to drive.

10. Musculoskeletal Handicaps

Discussions of musculoskeletal problems often included the related coordination problems associated with brain damage. A partial list of the conditions treated in this section includes: amputees, poliomyelitis, paraplegia, hemiplegia, spinal cord disorders, muscular dystrophy, multiple sclerosis, spina bifida, congenital deformity, and arthritis.

A number of articles (Frieden et al., 1969; DeLateur and Lehmann, 1969; Rehabilitation Record, 1972) discussed cases of persons with severe physical disability (e.g., hemicorporectomy, severe quadriplegia) who have been able to learn to drive and apparently to drive safely. The indirect reporting of similar experience was seen in descriptions of special driver education programs. This ranged from simple reporting of successful (licensed) driver education graduates (Berner, 1968; Match and Miller, 1969; Mathias, 1972; Steensma, 1975) to reports of driver licensure success or failure for more defined musculoskeletal diagnostic categories (e.g., orthopaedic, cerebral palsy, delicate--Reynolds, 1968; traumatic paraplegic/quadriplegia, post-polio paraplegia/quadriplegia, spina bifida, osteogenesis--Urie, 1975). An acknowledged expert in the field, Jiri Sipajlo (1975), reported a large number of severe quadriplegic and hemiplegic clients who, with intensive individual instruction, were able to obtain New York State driver's licenses and drive in New York City. Unfortunately, no follow-up data on the driving behavior of persons from these programs were available. It is difficult to obtain such information because of the expense involved in reaching a significant sample after several years of driving exposure.

There have been a number of empirical studies. In a survey of 100 selected physically handicapped drivers, Mach (1971), in West Germany, determined that 95 were able to drive safely with only appropriate changes in the automobile. Using a simulator and 45 college-age subjects, Johnson and Lauer (1937) tested an induced driving handicap, that of using only one arm. It was found that "errors" were not related to one-handed driving. It was found that a person using one arm drives about 8% slower. The authors suggested that this was compensatory behavior because they found little loss in manipulative efficiency due to the use of one arm only. In Denmark, Bogh and Poulsen (as seen in Goodwill, 1974) also reported differences between disabled (poliomyelitis and other non-brain damage associated musculoskeletal handicaps) and normal persons on three psychomotor tasks (normal movement of foot from accelerator to brake; movement of hand from wheel to hand-unit brake; operation of a telegraphic key).

In an often cited similator study McFarland et al. (1968) studied the physical components of steering and braking for 20 non-impaired non-commercial drivers, 20 non-impaired commercial drivers, and 60 amputees. McFarland reported that there was no evidence from the study that orthopaedically impaired persons (unilateral handicap) who were able to pass conventional driver licensing road tests, performed any more poorly on tracking or braking tasks than did the other participants in the study. He did mention that the experimental task conditions were simple (subjects were not required to time-share their extremities between two tasks). He also noted that a high percentage of these amputees had unresolved emotional problems and, therefore, suggested that psychological screening before licensing might be important.

In a large but not well controlled study (age, sex, and exposure complications), Crancer and McMurray (1968) investigated the accident and violation rates of Washington State medically restricted drivers. They found that the group with stablized physical handicaps (e.g., paralysis, amputees, and certain visual defects) had statistically higher accident rates. In a somewhat controlled investigation, the Washington, D. C. DMV found that an age stratified, randomly selected group of 50 orthopaedically handicapped drivers had an accident rate no greater than the accident rate for the average Washington, D. C. driver.

Ysander (1966) studied 494 disabled drivers, the majority of which had a loss of function in the legs usually due to either amputation or poliomyelitis. Using a control group matched for sex, age and license-holding period but with shorter exposure to traffic, he found that the disabled drivers, as a group, had fewer accidents. He did suggest, however, that disabled drivers with a loss of function on the right side had a somewhat greater percentage of accidents than did other handicapped drivers within the group. Dreyer (1973) in a study for the State of California DMV, studied the accident rates of 694 handicapped drivers (drivers with license restrictions requiring hand controls, steering knobs, and artificial legs). In a comparison with a randomly selected group of 1,237 normal drivers, who were more likely to be male, single and older, he found that the handicapped group had a similar involvement in total accidents and a lesser number of convictions than did the normal driver. Dreyer did not, however, have any control for exposure. In 1974, Hymen surveyed the 663 hand-control drivers in Washington State. She found no differences in accident or violation rates between hand-control or normal drivers.

Numerous guides offer licensing examination guidelines for the handicapped group under discussion (Nova Scotia Committee on Traffic Accidents, 1965; American Medical Association, 1968; USDHEW, Public Health Service, 1969; Hartmann, 1971; Waller, 1973; Quebec Department of Transport, 1973; Canadian Medical Association, 1974; Koschlig--East Germany, 1974). The most recent Physician's Guide for Determining Driver Limitation was published by the Committee on Medical Aspects of Automotive Safety of the American Medical Association in 1968. They noted that all orthopaedic impairments must be carefully evaluated on an individual basis. They stated that the client must generally have sufficient strength to turn the steering wheel, apply the brakes, reach the controls either by mechanical attachments or by appropriate prosthetic devices. Specific information was provided for five body regions: head and neck, the thoracic region of the spine, the lumbar region of the spine, the upper extremities, and the lower extremities.

They (AMA, 1968) stated that even significant restriction in head and neck movement was compatible with the safe operation of private vehicles because mechanical aids were available which could compensate for this type of impairment. Special cases which may contraindicate driving are: clients wearing neck casts or braces which severely restrict movement and clients with spastic torticollis.

Clients with disabling conditions of the thoracic region of the spine were generally advised against driving a commercial vehicle. Those with arthritis, if associated with unusual or painful restrictions of motion or respiration excursions usually should be advised not to drive. However, individuals with the proper compensating devices could drive. Clients with interscapular pain causing restriction of motion in the shoulder joint and increased vulnerability to fatigue should be advised not to drive until they recover.

Persons with severe cases of scoliosis accompanied by painful arthritis should be advised not to drive. Persons wearing braces should be evaluated on their ability to manipulate a motor vehicle safely. Those with extensions under the arms which could interfere with circulation are usually unable to drive safely.

Persons with osteoporosis should be warned that they may need bucket-type seating and other restraints. Patients with myeloma of ribs and spine should also be advised to use proper supports and restraints.

According to this guide, the lumbar region of the spine should be normal for drivers of commercial vehicles, but lumbar abnormality does not necessarily incapacitate an individual and preclude safe operation of a private vehicle. Persons with lumbar deformities, stiffness, and neuromuscular deficits from cord to nerve root defects should restrict their driving. However, many persons with arthritis, osteoporosis, congenital anomalies, and scoliosis could drive with the aid of power steering, power brakes, and automatic transmission. Persons with herniated lumbar discs should not drive while in severe pain.

Normal functioning of the upper extremities was recommended for drivers of passenger transport and commercial vehicles. Persons with one good arm could operate a private vehicle that has automatic transmission, power steering, and a wheel button. A person with one arm and one leg can drive but may require the balancing effects of proper prostheses. The strength of the hands was of basic importance, although prosthetic devices may be acceptable.

Normal functioning of the lower extremities probably was necessary for drivers of commercial vehicles, but with good arms the absence of both legs may not prevent the safe driving of a private vehicle if proper prostheses and controls are used.

This Guide also included a number of other disorders or disease processes under the topic of musculoskeletal since they impact on muscular control or coordination. Those listed were: paralysis agitans, poliomyelitis, hereditary chronic progressive chorea with mental deterioration, multiple sclerosis, hereditary sclerosis, syringomyelia; muscular dystrophy, cerebral palsy, myasthenia gravis, tumors of the brain and spinal cord, amyotrophic lateral sclerosis, post-traumatic syndromes, and intracranial suppurative processes which may affect muscular control and coordination. The Committee then described four specific disorders which could cause problems:

- Cerebral palsy: Clients suffering from this disease should be evaluated according to the degree of their spasticity providing there are no severe neurological complications.

- Pseudohypertrophic progressive muscular dystrophy: Since this was a progressive disease, clients needed frequent evaluations.

- Rheumatoid arthritis: Clients may require adaptive devices in order to drive safely.

- Rheumatoid spondylitis: These clients may have limitation of motion in entire spine and peripheral joints as well as a general weakness which may contraindicate their driving.

In general, the Committee recommended that it was the physician's responsibility to recommend that a client with a progressive disease discontinue driving when the disability reaches a point where driving may become unsafe.

In 1969, the Public Health Service of the USDHEW suggested a procedure for evaluating functional musculoskeletal performance. Table 5 and the next section have been taken from their publication.

Table 5. Motor Power and Acceptable Level of Function for Driver Licensure

Group	I Passenger Transport	II Cargo Transport	III Private Auto	IV Periodic Reevaluation	V Limited License
A	yes	yes	yes	no	no
B	no	no	yes	yes	no
C	no	no	(Individual consideration)	yes	yes

- Motor Power Requirements

The muscles of the right lower extremity and both upper extremities are the ones most commonly called on to perform the tasks of driving. The testing of these muscles was based on two factors: the force of gravity and the resistance applied by the examining physician to the muscle group being tested. The determination of muscle strength should be based on the physician's interpretation as to whether the strength is:

Normal--Complete range of motion against gravity with full resistance.

Good--Complete range of motion against gravity with some resistance.

Fair--Complete range of motion against gravity without resistance.

Poor--Complete range of motion with gravity eliminated.

Trace--Evidence of slight contractility, no joint motion.

Zero--No evidence of contractility.

Group A

Normal muscle power was tested at all of the following joints:

Right ankle dorsi and plantor flexion.

Right knee extension.

Hip flexion and extension.

Grip--both hands.

Both wrists--extension and flexion.

Both elbows--extension and flexion.

And at least good muscle power in flexion of the right knee.

Group B

Muscle power classified as good or better at any one or more of the following joints:

Right ankle dorsi and plantor flexion.

Right knee extension.

Hip flexion and extension.

Grip--both hands

Both wrists--extension and flexion.

Both elbows--extension and flexion.

And at least fair muscle power in flexion of the right knee.

Group C

Fair muscle power at any one or more of the following joints as listed in Group A and B.

And poor or worse muscle power in flexion of the right knee.

- Active Range of Motion of Joints

Along with sufficient motor power, a driver must have adequate mobility of the joints that are important to the safe operation of a motor vehicle. The wide variety of models, makes and design years make it impossible to generalize on the degree of joint motion necessary for any single motor vehicle. In some cases, a driver's license applicant may compensate unusually well for his condition and be able to operate a motor vehicle safely. All evaluations of this kind should be based on individual consideration by the examining physician and on the performance of the road test.

- Amputations

Loss of a part or the whole of a critical limb may not impair driving skills in the private vehicle but may in the commercial vehicle. With the devices available today, the amputee may drive safely in most traffic situations. For cases brought before medical advisory boards for review, individual evaluation was required.

New regulations for licensing the physically handicapped in Switzerland were suggested in 1971 (Hartmann). For driving a private automobile a person had to be a minimum of 155 cm (5'1") tall and have no malformations of the chest or spine which would considerably diminish breathing or mobility. With respect to extremities, the person must have no mutilation, stiffening or paralysis which cannot be corrected sufficiently with specific devices in the vehicle.

In his book, Waller (1973) stated that various chronic or recurring conditions may affect coordination of functional driving mobility. He felt that persons who have stable conditions (e.g., amputations) required evaluation by means of a practical driving test only once. For those handicaps where functional disability may be episodic, he recommended annual reevaluations. When episodes become more and more frequent, driving must not be permitted. Waller was generally of the opinion that medical conditions were not the cause of many automobile accidents.

In 1973, the Quebec Department of Transport published a licensing guide. The guidelines required that persons with disorders of the musculoskeletal system must prove to the motor vehicle bureau examiner that they were capable of reaching all the control mechanisms of the motor vehicle for which they are requesting a driver's license. Additionally, they must prove that they have enough strength and freedom of movement to ensure their normal functioning. Those needing a prothesis or brace must show that they are capable of driving an automobile without difficulty. The following information has been summarized from that Guide.

- Cervical Vertebrae

Applicants suffering from a traumatic or inflammatory lesion of a cervical vertebrae should not drive an automobile until cured. Pain or discomfort, on the other hand, should not prevent the driving of a private vehicle weighing less than 6,000 pounds and equipped with an exterior rear view mirror. Such applicants should not drive a public vehicle.

- Dorsal Vertebrae

Persons having a marked malformation of the dorsal vertebrae or who cannot move without pain in these vertebrae should not drive public vehicles. Persons whose movements are not excessively impaired may drive a private vehicle whose maximum curb weight does not exceed 6,000 pounds.

Persons suffering from severe pain in the interscapular region which restricted shoulder movements should not drive an automobile. Benign or moderate scoliosis ordinarily would not prevent a person from driving safely; persons having pronounced scoliosis causing severe pain or excessive fatigue should not drive.

Persons wearing a plaster-of-paris jacket or an orthopaedic corset may drive a private vehicle whose maximum curb weight is under 6,000 pounds.

Persons having osteolytic lesions of the spinal column must use a shoulder brace and safety belts to prevent any lesion of the vertebrae as the result of a sudden stop.

- Lumbar Vertebrae

Individuals suffering from lumbar malformations, stiffness, or neuromuscular problems caused by radicular or medullary compression may drive vehicles with restrictions based on the type of movement and the muscular strength of the legs.

- Arms

To drive a public vehicle without danger, the applicant must be able to use the arms freely in a pain-free manner. The two hands must be able to grasp the steering wheel with enough strength to maintain balance and control in a sudden stop. Therefore, the applicant must have a sufficient number of fingers and a thumb to assure a strong grip. Persons having functional hand disorders must prove their ability to grasp the steering wheel firmly.

Persons with only one arm can usually drive a private vehicle whose curb weight does not exceed 6,000 pounds if they always have complete control of the steering wheel and must not let go of the wheel to control other mechanisms.

- Legs

Persons whose movements were limited or whose muscular strength or coordination were impaired may drive a properly equipped private vehicle with restrictions. Persons who suffered from paraplegia or paraparesis often required special equipment in order to drive safely.

The following table, taken from the Quebec Guide, lists the various types of licenses which may be obtained depending on the type and degree of amputation or ankylosis.

The restrictions on this table apply only to persons whose amputation was recent or those requesting a license for the first time. Persons whose amputations were not recent and who had become accustomed to driving in a manner which compensates for their handicap would not be subject to the restrictions applying to those having recently undergone amputations.

In 1974, the Committee on Emergency Services of the Canadian Medical Association prepared a guide for physicians. They noted in their introduction that there was little scientific evidence which can be used to assess the degree of impairment to driving that results from any specific disability. Their standards were intended only as a common sense guide in the placement of restrictions upon drivers. The guide suggested that in his examination the physician should try to assess not only the physical but also the client's emotional status.

Table 6. Physical Handicaps

Handicap	Limb	Category of license: 1-2*	Class of vehicle	Restrictions
Amputation	Arm Elbow Forearm Hand Five fingers	1	Excluding public vehicles	
		2	Private vehicles	H-Vehicle maximum curb weight 6000 lbs. J -Automatic transmission K-Power steering or spinner knob on steering wheel M-Foot controlled wipers
Amputation	Four fingers	1	Excluding autobuses	
		1-2	Other vehicles	No restrictions where prehension is firm. Otherwise, the person is considered as having only one hand. Prehension is considered good if the person has at least the first phalanx of the thumb and the first or second phalanges of the fingers.
Ankylosis or limited flection	Elbow	1-2	Public or other vehicle	No restriction if the limitation or ankylosis falls between 45° and 135°, if there is no pain, if there is supination and if the hand and wrist are normal.
		1-2	Excluding public vehicles	If the limitation or ankylosis is less than 45° or greater than 135°, the license will be granted after a study of the contents of the report and the following restrictions will usually be made:
			Private vehicles	H-Vehicle maximum curb weight 6000 lbs. K-Power steering or spinner knob on steering wheel
			Private	Muscualr strength and supination movement of the forearm will also be taken into consideration.

Table 6. Physical Handicaps (Cont'd)

Handicap	Limb	Category of license 1-2*	Class of vehicle	Restrictions
Amputation	Hip Thigh Knee	1	Excluding public vehicles	
		2	Private vehicles	H-Vehicle maximum curb weight 6000 lbs. J- Automatic transmission Q-Manual dimmer light switch or magic eye R-Accelerator on left side (for new amputee-right thigh)
Ankylosis or limitation of movement	Hip Knee	1	Excluding autobuses	
			Other vehicles	Restrictions will depend on the angle of ankylosis or the degree of limitation of movement as regards the category and class of license requested.
Amputation	Leg Ankle	1	Excluding autobuses	
		1-2	Other vehicles	H-Vehicle maximum curb weight 6000 lbs. J- Automatic transmission ** Q-Manual dimmer light switch or magic eye ** R-Accelerator on left side (for a new amputee-right leg) If the leg is amputated at the knee, the patient is considered a thigh amputee. If the amputation is at the ankle, he is considered as a leg amputee.
Amputation	Ankle Foot Toes	1-2	All vehicles	Ankylosis of the ankle, amputation of the foot (tarsal or metatarsal) replaced by a prosthesis, and amputation of the toes will not usually result in restrictions on a driver's license or in a change of category or class, except when judged necessary following a study of the medical file concerned.

* Driver's License Classification: Type #1-Chauffeur; Type #2-Operator

**May not be required if there is a functional prosthesis.

In general they felt that the ability to maintain posture and to coordinate movements of the head and limbs were essential for safe driving. A number of conditions can cause poor coordination or poor muscle control. Included in this group of diseases were: poliomyelitis, Parkinson's disease, multiple sclerosis, cerebral palsy, muscular dystrophy, myasthenia gravis, tumors of the brain and spinal cord, organic brain damage following a head injury and many others.

In the early states of some of these conditions no restrictions were needed and if the disorder was not progressive only one examination was required. However, if the disease was progressive, the applicant should be reexamined at regular intervals and driving discontinued when the disability reached a point that made it unsafe. In some of these conditions, however, if a slowing of the thought processes is liable to lead to loss of consciousness, the applicant should not drive any motor vehicle.

Occasionally, an applicant with a mild loss of muscle control might require mechanical appliances added to his car. The driving examiner knows the appliances that would be approved and can give advice on what equipment was available and where it could be purchased. When an assistive device has been installed, the applicant must satisfy the examiner that he can drive safely.

The motor vehicle driver with other musculoskeletal disabilities must be evaluated in terms of his ability to perform automobile control movements quickly, accurately, and repeatedly. The Canadian Medical Association noted that in some cases the best method of assessment was through a road test conducted by the driver examiner. The Committee's other guidelines for disabilities of the limbs were nearly in agreement with those of the Quebec Medical Association.

In the evaluation of any of these conditions, the interaction of therapeutic drugs must also be considered since these could either enhance or degrade driving ability. Most guidelines do not comment on the impact of therapeutic drugs on safe automobile driving although they have a separate section on drugs which may affect driving. At least one article did mention the testing of one muscle relaxant (carisoprodol). Miller (1962) found that 700 mg. (considered normal therapeutic dosage) taken over a two-week period had no effect on a simulator driving task. Dokert (1970) states that the impact of muscle relaxants was probably minimal since they were generally only used in hospitals.

All but ten states had statutes which empowered the Commissioner of Motor Vehicles either not to issue a driver's license to, or not to renew the driver's license of, any person thought by reason of physical or mental disability not able to operate a motor vehicle safely (National Committee on Uniform Traffic Laws and Ordinances, 1975). In 1972, Manus and Less surveyed the states in an attempt to summarize the policies and procedures which were used in testing and licensing the disabled driver. They did not find much uniformity and at times they found confusing, non-directive, and misleading regulations. They felt that the general trend was to license the person with stable conditions as long as he drove with the special equipment used during the road test. Persons suffering from unstable conditions were more likely to be licensed but with provisions for restricted driving. This seems to be borne out by the treatment of stable and unstable handicaps in the legal literature. Most legal cases dealt with unstable muscle or coordination problems where neurological complications may spasmodically interfere with safe driving.

In 1963 (American Law Reports, 1971), the courts reversed the license suspension of a person suffering from multiple sclerosis. Undisputed medical testimony was introduced to the effect that this person's spastic paraplegia, with complete paralysis of the lower extremities, would not prevent him from safely operating a hand controlled vehicle. Additionally, he could overcome double vision (due to multiple sclerosis) by simply closing one eye. In another case in 1955 (American Law Reports, 1971), a person having had a stroke and suffering from hypertension, arterial changes, and limited motion of the left arm and leg was not allowed the continued use of her automobile.

Persons with musculoskeletal handicaps could have problems with strength and motion, coordination, perception and cognition. All of these could impact driver education. Many programs utilized pre-education assessment to screen students from programs or to place them within programs. This assessment was often done by a team of specialists (Hofkosh, 1969; Brown, 1975; Steensma, 1975; Odhner, 1975) and could include an intensive interview, the use of psychological and psychophysical tests, and an intensive medical examination. Most important for this group might be a simple test to determine the ease or difficulty with which a client can enter and leave a vehicle (Hofkosh, 1970; Odhner, 1975).

Next in importance was the determination of whether the client has suffered any brain damage which could affect his visual, perceptual, or cognitive abilities. This could be done either by using paper and pencil tests (Hofkosh et al., 1970) or some means of simulation. Brown (1975) stated that a simulator was used by physical and occupational therapists to evaluate perceptual and motor skills. Odhner (1975) used a simulator to test reaction time, startle reflex, grip strength in dominant arm (20 lbs. minimum), ability to press down and pull back on hand controls (10 lb. minimum), and the ability to turn the steering wheel 360 degrees. After a program of instruction was begun, continual assessment was required to determine or focus on individual needs.

Many curricula were adaptations of existing curricula for normal students. Reynolds (1968) studied the practicability of teaching automobile driving to physically disabled high school students. His curriculum was very similar to the regular driver training program used in Los Angeles city schools. Generally, more time was required to teach these students than was normally used for regular students. Three groups of students were taught: orthopaedic (loss, or loss of use, of one or more extremity or handicap involving the spine), cerebral palsy (limited to severe orthopaedic involvement), and delicate (epilepsy, heart disease, asthma, hemophilia). Success in obtaining licenses was greatest for the orthopaedic group and least for the cerebral palsied groups. The greatest problem encountered in the teaching process was the isolation of perceptual difficulties. The mechanical skills required for vehicle operation were reported to be much less a problem.

Modes of instruction often included the use of simulators (Florio, 1971; Goble, 1975). Long (1974) discussed the Highland View Hospital programs in which simulator performance was used to screen for entrance into the behind-the-wheel phase of instruction. Those who complete phase one successfully were likely to be successful in obtaining their driver's license. Others (Hofkosh, 1969) felt that simulators were of limited use due to their lack of kinesthetic sensation and limited peripheral vision input.

In-car instruction was often preceded by tests for visual or perceptual deficits. Sipajlo (1969) described some basic maneuvers of behind-the-wheel evaluation. These were the critical exercises of: changing direction from clockwise to counterclockwise, changing pattern from circles to figure eight, and changing direction while in a figure eight pattern. Sipajlo classified client performance as: without difficulty, subtle difficulty, and obvious difficulty. Clients who did not experience any difficulty were then evaluated for proper assistive devices and recommended for complete training. Those who experienced subtle or obvious difficulty were usually trained in better visual screening procedures. If no progress was noted by the end of the evaluation, they were advised not to drive pending re-examination (usually scheduled within one year). Other programs used similar procedures (Ramsey, 1975).

Psychological factors were capable of having a significant impact on driver education. McFarland (1968) noted in his psychological examinations of amputees that they were likely to exhibit chronic depression. Bardach (1969) suggested that persons with traumatic injuries should not relearn to drive until they had adjusted to their new body image. In 1971, Bardach studied 31 patients who were rated as difficult by driving instructors. Diagnostically, the patients demonstrated various kinds of neuroses and character disorders. Bardach noted that these problems seemed generally less salient in the brain-damaged group (hemiplegics) than in the non-brain-damaged group. Kirk (1972) also noted problems of maladjusted behavior in outlining problems associated with educating exceptional children.

11. Hearing Handicap

As has been stated in a previous section (Driving Task) very little is known about the auditory requirements necessary for safe driving. In 1973 Henderson and Burg studied the auditory requirements for truck and bus driving. They found none which were directly related to behind-the-wheel performance. In 1974 they studied the auditory requirements necessary for the safe driving of a private automobile. Only one critical task had auditory requirements. They felt that this may have been more a function of the analytical procedures used to isolate tasks than an accurate assessment of audition's role in safe driving. In a recent simulator study, however, McLane and Wierwille (1975) found that the deletion of a velocity-dependent auditory cue (engine noise) did appear to contribute to a deterioration in a suggested measure of safe driving. In general, Henderson and Burg (1974) stated that the components of interior and exterior noise more than likely combined to minimize the impact of auditory cues on driving.

Expert opinion usually agreed in favor of the deaf driver (Mirkin, 1967; Fox, 1969; Misner, 1975) although Cheetham (1974) felt that at least in South Africa the deaf were likely to be involved in an accident with serious consequences. Judge Sherman Finesilver had cited the "good" accident record of deaf drivers many times. In a USDHEW publication he described a study (no controls) comparing 100 deaf Colorado drivers to two groups of 100 hearing drivers. The deaf drivers had both fewer violations and fewer offenses. Finesilver stated that the deaf drivers' ability to concentrate (no auditory distractions) may enable them to be better drivers.

Somewhat more controlled surveys or studies have been reported by Roydhouse (1976), Henderson and Burg (1973), and the Washington, D. C., Department of Motor Vehicles (1973). Roydhouse described a survey conducted among deaf drivers in New Zealand. Self-reported accident data over a five-year period were solicited from 220 deaf drivers. The younger drivers (under 50 years old) had a lower accident rate than the national average while the older drivers (over 50 years old) had a higher accident rate. Henderson and Burg studied accident records of 250 truck and bus drivers (with different degrees of hearing loss) and found that the greater the person's hearing loss the lower the accident rate. The Department of Motor Vehicles in Washington, D.C. studied the accident rates of medically impaired drivers. Based on an age-stratified, random sample of 50 deaf licensees, it was found that this group had better than average driving records.

In 1968 Schein reported on another Washington, D.C. study. Comparing simple automobile and violation rates (deaf versus general population) Schein found that deaf drivers had less than one-third the number of accidents and only one-fourth the number of violations.

Two studies were done by the California State Department of Motor Vehicles. In 1963, Coppin and Peck reported that a sample of deaf drivers had 1.78 times as many accidents and 1.26 times as many convictions as did the non-deaf. In this study, however, the deaf differed from the non-deaf on a number of variables: mileage, occupation and sex. In 1964 two large samples of deaf and non-deaf were matched on five variables: age, annual mileage, occupation, sex and area of residence. It was found that deaf females did not differ significantly from non-deaf females on either accidents or violation points. The deaf male sample had an accident rate 1.8 times higher than the accident rate of the non-deaf male sample. With regard to violations, the males did not significantly differ from each other. The deaf male drivers selected for comparison had come from the Los Angeles and San Francisco areas. They had demonstrated a higher accident rate than had the male deaf drivers from other geographical areas of the state.

The recommendations for licensing the deaf or hard of hearing often contain introductory remarks stating that these persons can often compensate for their handicaps by increased visual vigilance (American Medical Association, 1968; Canadian Medical Association, 1974). The Nova Scotia Committee on Traffic Accidents (1966) recommended that deaf or hearing impaired private automobile drivers use an outside rearview mirror. Deafness was disqualifying in the operation of passenger transport vehicles but not necessarily for the operation of commercial or private vehicles except in cases where the person was totally deaf according to the CMA.

The American Medical Association in its 1968 physician's guide briefly remarked that deafness could be a handicap in the safe operation of an automobile, but that it was usually compensated for quite well. However, it said that complete deafness did disqualify persons from operating passenger transports and other commercial vehicles but not from the operation of a passenger vehicle.

The USDHEW Public Health Service (1969) defined "hard of hearing" as the inability of a subject to pass a voice recognition test (the ability to correctly identify four out of five numerals spoken in each ear with the examiner standing 2 feet behind the patient), or any equivalent test selected as appropriate by the medical advisory board. It suggested that such individuals whose cases have been referred to the advisory board be grouped as follows:

Group A--Hard of hearing from before the age of 15 years;

Group B--Became hard of hearing after 15 years of age and has been aware of deficiency for more than 4 years;

Group C--Became hard of hearing after 15 years of age and has been aware of deficiency for less than 4 years.

In the absence of other adverse factors, individuals in all the above categories may be recommended for a private passenger vehicle license with these restrictions:

- Those in Groups A, B and C should drive only in vehicles equipped with two side mirrors in addition to the inside rearview mirror.
- Those in Group C, in addition to the above requirement, should have satisfactorily completed a course especially designed for the deaf driver.

There were relatively few deaf people employed as drivers of cargo transport or passenger transport vehicles. Hence, there was a scarcity of data which could either support or refute the capability of the deaf individual to drive such vehicles safely. From the medical standpoint, the USDHEW guidelines deem it logical to recommend licensing under the same restrictions suggested for Group C for drivers of private passenger vehicles. The advisory board would need to consider existing state laws and regulations on this matter and might well consider the possibility of license limitations in connection with either cargo or passenger transport involving special hazards.

The Swiss Government legal regulations covering hearing loss and automobile driving were discussed by Hartmann (1971). In order to drive private vehicles the person must be capable of hearing normal conversation at 8 meters (26 feet) without aid. Commercial and transport drivers required two-sided conversational hearing at 3 meters (10 feet) without aid; with one-sided deafness these drivers must have a 6 meter (20 feet) conversational hearing capability in their good ear without aid.

The Quebec Department of Transport (1973) in their medical guide offered some specific recommendations to evaluate hearing. Candidates with a varying hearing loss in one or both ears could usually drive a pleasure or commercial vehicle without undue danger, if the vehicle was equipped with a rear-view mirror on the side of the impairment. Those making application for a chauffer's license with a suspected hearing difficulty would require a medical report with audiogram indicating the percentage of discrimination for each ear. However, public vehicles in which the driver must speak to the passengers required more stringent regulations. Minimum decibel hearing levels as determined by the American National Standard Institute have been employed. The distraction of speaking with passengers in noisy vehicles could well be dangerous. On the other hand, if the driver does not have to speak with passengers, the decibel levels have been somewhat relaxed.

Waller (1973) noted Coppin and Peck's 1964 study and suggested that persons with severe hearing loss (greater than 50 decibels at 2,000 hertz in the best ear after correction) should be permitted to drive using special mirrors but then only during the daytime.

The Committee on Emergency Services of the Canadian Medical Association (1974) stated that persons with a loss of hearing acuity usually could compensate for their handicap. They required an audiogram for all classes of vehicles other than a motorcycle. An applicant for a license should be referred for a pure tone audiogram if any hearing loss is suspected.

The Committee further felt that passenger transport and commercial vehicle operators should not have a significant hearing loss. A loss of more than 40 decibels on the 1964 ISO scale at 500; 1,000 and 2,000 HZ on a pure tone audiometer in either ear was significant if the applicant was driving a passenger carrying vehicle. A loss of more than 40 decibels in both ears was significant if the applicant was driving a heavier commercial transport vehicle. The Committee also stated that a hearing aid may be of some value in the operation of a private vehicle but was generally of little help in improving the hearing of the driver of a noisy passenger transport or commercial vehicle.

All but ten states in the United States have statutes which impacted on the licensing of persons who have hearing loss. Following the general rule that an automobile driver must: a) be physically competent to drive a car, and b) possess the requisite skill and experience (Corpus Juris Secundum, 1975), several cases have interpreted "requisite skill and experience" to mean "sufficient to drive a vehicle with reasonable safety." This means that the operator was not required to possess the highest degree of skill. The cases have determined that the hearing impaired driver can use his other faculties to offset his disability and, therefore, conform to the standard of care required of all drivers.

The greatest problem in teaching the deaf was, of course, the communication aspect. The severity of this problem was related both to the degree of hearing loss (Kirk, 1972) and to the age at which the person first became impaired. The earlier the loss and the later formal education began, the more difficult all communication becomes.

A number of driver education programs taught the deaf driver (Fox, 1969; Cunningham, 1970; Layton, 1974; Misner, 1975; Champagne, 1975). Modifications to a normal curriculum usually include additional visuals (often captioned--Cunningham, 1970) for visually communicating to the student while he is driving, additional dashboard lighting (Champagne, 1975), and sometimes special in-ear devices. A number of programs relied on simulators for practice in order to minimize hazardous first time behind-the-wheel experiences. Generally, the deaf were noted as being especially alert behind the wheel.

The psychological aspects of hearing loss as they related both to counseling and education have been discussed by Levine (Garrett and Levine, 1972). A very supportive learning environment was required for the persons who suffer either from prelingual hearing loss or from progressive hearing loss.

12. Respiratory Conditions

There is practically no objective research information concerning the effect of respiratory conditions and driving performance. Norman (1960) reported two bus drivers in ten years who lost consciousness during work. The one who had whooping cough also had an accident with another vehicle; the other had lobar pneumonia.

There are, however, several opinions about the licensing of people with respiratory conditions. Wallner (1973) and the Canadian Medical Association (1974) recommended that a person who climbs one flight of stairs or walks on a level surface for 100 feet and has dynpnea or cor pulmonale should not be allowed to drive. The Swiss, according to Hartmann (1971) will not permit individuals to drive if their driving performance is diminished because of breathing difficulties.

A detailed guideline for general respiratory function was presented by USDHEW (1969). Impairment to driving caused by ventilatory deficiency may be grouped as follows:

- Group A--Chest X-rays are usually normal but may show healed or inactive disease of the chest. Dyspnea, if it occurs, is consistent with the type and degree of physical exertion. Values obtained from at least two of the ventilatory function tests are no less than 85 percent of predicted normal values for patient's age, sex, and height. Blood gases are usually within the normal range.

- Group B--Chest X-rays are normal or abnormal. Dyspnea does not occur at rest and usually does not occur during the performance of usual daily activities. The subject can keep a normal pace with persons of his same age and body build on level ground without breathlessness, but not on hills or stairs. Values obtained from at least two of ventilatory function tests are in the range of 70 to 85 percent of the predicted normal values. Blood gases usually are normal but the oxygen partial pressure present on a random sample of arterial blood may be diminshed to 75 mm. Hg.

- Group C--Chest X-rays may be normal but usually are not. Dyspnea does not occur at rest but is present during performance of usual daily activities. The individual can walk one mile at his own pace without dyspnea but is unable to keep up with his peers. Values of at least two ventilatory function tests are in the range of 55 to 70 percent of the predicted normal values. The blood gases are usually abnormal with the partial pressure of arterial oxygen no less than 70 mm. Hg.

- Group D--Chest X-rays are usually abnormal. Dyspnea occurs climbing one flight of stairs, walking 100 yards on the level, or even at rest. Values obtained from at least two ventilatory function tests are below 55 percent of the predicted normal value. The partial pressure of arterial oxygen is less than 65 mm. Hg.

Table 7. Acceptable Levels of Respiratory Function for Driver Licensure

Group	I Passenger Transport	II Cargo Transport	III Private Auto	IV Periodic Reevaluation	V Limited License
A	yes	yes	yes	no	no
B	(Individual consideration)		yes	yes	yes
C	no	no	yes	yes	yes
D	no	no	no	yes	no

Both the Canadian Medical Association (1974) and the Quebec Ministry of Transport (1973) recommended that people with infectious tuberculosis should not drive vehicles carrying passengers. The Swiss agreed but also stated that people with active tuberculosis should not drive even private vehicles.

Driver applicants with emphysema and persons who are subject to disabling attacks of asthma should be evaluated on an individual basis and in light of the type of vehicle they wish to drive (Canadian Medical Association, 1974).

It was usually safe for people having undergone a permanent tracheotomy following a laryngectomy to drive restricted-weight private vehicles, but not public ones (Canadian Medical Association, 1974; Quebec Ministry of Transport, 1973; American Medical Association, 1968; Nova Scotia Medical Society, 1965). However, people with injuries or deformities of the mouth or throat which seriously interfere with breathing cannot safely operate any type of motor vehicle (Canadian Medical Association, 1974; American Medical Association, 1968).

13. Adrenal Disease

People with adrenal cortical hyperfunction (Cushing's disease) who develop muscle weakness and osteoporosis should not drive any type of vehicle. If they improve with treatment, they may be able to drive a private motor vehicle. (Canadian Medical Association, 1974; Quebec Ministry of Transport, 1974; American Medical Association, 1968; Nova Scotia Medical Society, 1965).

Patients with Addison's disease, particularly those with asthenia or a persistenly low blood pressure should be advised not to drive a motor vehicle unless the symptoms are mild and well controlled by therapy, in which case they may operate a private motor vehicle only. (Canadian Medical Association, 1974; American Medical Association, 1968; Nova Scotia Medical Society, 1965).

Hyperfunction of the adrenal medulla due to the development of a pheochromocytoma with paroxysmal hypertension, headaches, dizziness, and blurred vision is a contraindication to the operation of any type of motor vehicle until these symptoms are completely relieved by the removal of the tumor. (Canadian Medical Association, 1974; American Medical Association, 1968; Nova Scotia Medical Society, 1965).

14. Thyroid Disease

People who suffer from thyrotoxicosis, because of the co-existence of cardiac and emotional disturbances, should not be allowed to drive until their disabling symptoms are well controlled (Canadian Medical Association, 1974; Waller, 1974; Quebec Ministry of Transport, 1973; American Medical Association, 1968; Nova Scotia Medical Society, 1965). Also, those people with severe myxedemia or cretinism should not be licensed to drive. The Canadian Medical Association (1974) suggested that individuals with myxedema can drive if they respond to treatment. People who have enlarged thyroid glands with pressure symptoms can be licensed to drive private but not commercial vehicles (Canadian Medical Association, 1974; American Medical Association, 1968; Medical Society of Nova Scotia, 1965).

15. Parathyroid Disease

People with hyperparathyroidism who suffer from muscular weakness and hypotonia cannot drive. If the symptoms are benign and treatment is satisfactory, they may be authorized to drive private vehicles. (Canadian Medical Association, 1974; Quebec Ministry of Transport, 1973; American Medical Association, 1968; Nova Scotia Medical Society, 1965).

Acute hypoparathyroidism accompanied by neuromuscular excitability renders people unfit for driving. The affliction must be examined on the basis of the seriousness of the symptoms. When it is benign and does not show obvious signs of tetany, the person can drive private vehicles.

16. Pituitary Gland Disease

People suffering from diabetes insipidus could safely drive private vehicles as long as there was no sign of a disorder of the visual apparatus or central nervous system. If such symptoms exist, driving is forbidden. (Canadian Medical Association, 1974; Quebec Ministry of Transport, 1973; American Medical Association, 1968; Nova Scotia Medical Society, 1965).

When hypopituitarism resulted in periods of spontaneous hypoglycemia, the patient must be advised not to drive at all. If treatment is successful and the patient is followed closely by his physician, he can usually safely drive private vehicles. (Canadian Medical Association, 1974; Quebec Ministry of Transport, 1973; American Medical Association, 1968).

Patients with acromegaly who have begun to develop muscle weakness, pain, easy fatigue, visual disturbances, cardiac enlargement or intractable headaches cannot drive any type of vehicle safely (Canadian Medical Association, 1974; American Medical Association, 1968).

17. Renal Disorders

Ysander (1966) in a study of drivers with chronic diseases found that only 2.5% of drivers with renal disorders had accidents, and 7.7% of the matched group of normal drivers had accidents.

It was felt that persons with chronic renal failure who require intermittent dialysis, but who are otherwise in good health, can drive a private motor vehicle and light commercial or public transport vehicles safely provided they are always able to be dialyzed at the interval recommended by their physician. This means that, at the present time, such persons must limit their driving to about three hundred miles from home in order to avoid undue fatigue and provide a margin of safety for unexpected delays. Due allowance also must always be made for delays that may be caused by winter driving conditions. (Canadian Medical Association, 1974).

18. Cancer

One factor that is often overlooked as a cause of collapse during driving was carcinoma of the bronchus which commonly metastasizes in the brain and may cause seizures. However, Markel (1975) of the American Cancer Society reported there has been no problem with the licensing of cancer patients. The cancer patients are either obviously too sick to drive (and they do not) or they are completely able to drive.

19. Obesity

An extremely obese person may not be able to respond rapidly enough to an emergency situation and may not be able to operate the controls in a smaller car properly (Canadian Medical Association, 1974). Obesity could also constitute a handicap for a person required to drive a commercial vehicle. The exertion needed in commercial driving may be hazardous to the obese driver (Quebec Ministry of Transport, 1973).

C. Automotive Adaptive Equipment

The Eastern Paralyzed Veterans Association reported that as of 1961 an estimated one-third of three million seriously handicapped drivers used adaptive controls (American Medical Association Journal, 1971). There are certainly more in use today. Mach (1971) found that in a selected group of 100 physically disabled persons 95 were able to drive with appropriate changes in the automobile. However, Hyman et al. (1972) concluded in a review of the literature that available adaptive equipment allowed a limited group of the disabled to drive. From a strictly technological viewpoint, almost any physical disability could be accommodated; however, economic practicality and need limited the development to the most useful adaptive equipment (Peizer, 1975).

The American Automobile Association (1972) produced a catalog of manufacturers of automobile adaptive equipment. They also recommended which types of adaptive controls were used for various types of disabilities. DeBenedictes and Dougherty (1975) have catalogued several hundred special transportation vehicles or assistive devices available for the handicapped. This directory offers a brief description of the device, its operation, its cost, and other important statistics. Rodger (1975) presented a chart with the type of adaptive controls needed for various disabilities as well as the type of general vehicle equipment needed. Laurie (1973) described, in general terms, vans for the physically handicapped and presented a listing of manufacturers of wheelchair lifts, hand controls, ramps, etc. Scott (1974) described the state-of-the-art in safety for modified vans.

The President's Committee on Employment of the Handicapped (1974) recommended a partial list of requirements for automobiles:

- Door opening of 36" high plus clearance to admit wheelchair.
- Removable headrests to enable driver to bring in wheelchair.
- A minimum of 13-1/2" width in back seat area to hold wheelchair.
- Hand-operated emergency brakes and windshield washers.
- Front seat sunvisors strong enough to act as grab-bars.
- Front doors wide enough for easy access to the front seat by the paraplegic, and trunk and door height at a convenient level for a person in a wheelchair.

Rhoads (1974) also listed automobile requirements for the physically disabled:

- Two-door design
- Automatic transmission
- Power steering
- Power brakes
- Tilt steering wheel
- Power seat
- Power windows
- Electric door locks
- Arm rests (right and center)
- Inside adjustable mirrors
- Bench seats
- Citizen's band radio
- Rear window defroster
- Electric garage door opener
- Inside rail sling (for lifting)
- Mechanical lift (van)
- Wheelchair locks
- Contoured cushion seat
- Inside overhead grab-bar
- Sliding door
- Small ramp for wheelchair
- Seat rail
- Extended seat guides

Another author, Gresham (1974), added several additional requirements to the list above:

- Bucket seats
- Console
- Pivot front seat

Zorman and Klinger (1970) presented an overview on transfer of the physically handicapped into automobiles, automobile safety aids and accessories, parking and garages, automobile controls and adapted vehicles, as well as travel considerations for the handicapped driver. Zino (1972), in his article, described the minimum car requirements for instructing physically handicapped students.

There were also warnings for the physically handicapped. Oakland (1975) and Harden and Tenniswood (1973) pointed out that handicapped persons can be in trouble with power equipped vehicles if they have automobile motor problems. Many do not have the strength to handle the vehicle without power assistance. He recommended a back-up power system.

There were not many research studies in the area of adaptive controls and driver behavior. Goodwill (1974) studied the reaction times of 30 normal and 50 disabled persons. He found that the disabled reaction times--for movement of foot from accelerator to brake and movement of hand from wheel to hand brake unit--to be slower. Richter and Hyman (1974) found that a group of 15 drivers could activate hand controls and a pistol-grip controller with trigger-activated brakes faster than foot-operated brakes. In a somewhat controlled study in Washington State (Hyman, 1974), 663 hand-control drivers had equivalent accident and violation rates when compared to 104 nonrestricted drivers.

Peizer (1975) discussed his knowledge of the state-of-the-art of advanced adaptive equipment concepts. He described a vehicle control using movement of the eyebrows and the adaptive devices a litter patient could use to drive. Bray and Cunningham (1967) described the general need for development of vehicles for different critical levels of spinal cord function.

Huddleston et al. (1957) presented a case where a patient with very limited upper extremity function was able to drive his car modified with all foot controls. Kesterson (1975) described a special driving ring for amputees in place of the typical spinner knob on the steering wheel. They can open their hook and insert it in the ring. Reynolds (1975) designed a driving splint for support of the arm for quadriplegics not requiring the use of the triceps. Several possibilities for motorized controls were presented in Lehneis et al. (1969). Dunkel and Selwyn (1975) described their "Open-Loop Electric Steering System" for cars and vans that allowed reliable steering through foot switches.

Harden and Tenniswood (1973) described controls which bypass the normal pedals and connected directly to the servo-valve of the brake system and to the carburetor. These controls were designed for handicapped individuals who lack the strength and range of motion required to use the add-on type of adaptive controls. Almost all of the force required to operate the finger controlled brake comes from the vacuum power unit. This push button device gave real feedback for aid in the control of the vehicle.

Freeman (1974) reported that in 1970 Congress authorized purchase of adaptive automobile driving aids for disabled veterans. He tested 17 control systems and found that only five were safe. Peters (1973) reported that 17 different hand-control systems were purchased and tested. They were rejected because of safety hazards or generally low quality. He mentioned that installation was a highly specialized job requiring general automotive mechanical knowledge and specific understanding of the control system. No specifications, standards, regulations or requirements were in existence in the U. S. at the writing of this article. Tentative Federal standards for automotive adaptive equipment for disabled veterans were published in 1975 (Veterans Administration, 1975). These standards established safety specifications, operations requirements, and reliability standards for components of these devices.

The biggest problem for the wheelchair-bound person was getting into and out of the car (Goldberg, 1975). Dick and Gresham (1974) described a procedure for getting a wheelchair into a two-door car. They recommended two-door automobiles over four-door models because of additional room for entering and exiting. Goldberg and Davis (1967) also presented a technique of lifting a wheelchair into a two-door vehicle by a paraplegic.

Cunningham (1971) described the development of a special wheelchair which was adapatable to a two-door sedan, and among other things, could climb curbs. A description of the design and operation of an external hoist for wheelchairs which mounts on the roof of a vehicle was presented by Henshaw (1970). Rozin and Tolnai (1971) described now a specially designed wheelchair and reconstructed automobile were used to enable a triplegic patient to drive. Deyoe and Andersen (1970) reported the development of a transfer stool which assists quadriplegics in getting from their wheelchairs to the automobile driver's seat.

In England, Hall (1960) noted that the use of adaptive controls on English cars with manual transmissions was an unsatisfactory modification for persons without use of legs. Controls for the invalid car (three-wheeled) were designed for the handicapped. However, these cars are underpowered, unstable, and noisy. Millicamp (1970) also discussed the problems with England's poorly designed invalid cars. Another article described some improvements of the controls of the invalid car (Three-Wheeler Conversion Helps the Disabled, 1969). Dwoskin (1970) suggested that the British Mini car was a practical solution since handcontrols are easily fitted, and there was room for a wheelchair. He reported that the Mini was better suited for the physically handicapped than most American automobiles. A reaction to a mini-car with adaptive controls was also presented (Bailey, 1970).

V. RECOMMENDATIONS

This section identifies the most important additional research and development efforts needed in driver education and licensing of the handicapped driver. These recommendations were identified during the performance of the project and represent suggestions from both Phase I and II of the program. The order in which they are presented does not indicate preference or importance.

1. A more comprehensive analysis of the driving task for normal drivers. Of particular interest are those situations critical to safe driving. With a detailed analysis of the perceptual, cognitive, and motor aspects utilized in driving, it would allow for a more valid determination of the effects of medical disabilities on driving.

2. Detailed analysis of driving for various handicapped drivers. This would be a determination of those compensatory driving behaviors that are different from the able-bodied. From a comparison of normal and handicapped drivers, requirements for the handicapped for skills development could be determined. A separate analysis would be required for each disability.

3. A large scale eipdemiological type study to measure the accident and violation rates of specific handicapped groups. To date, most epidemiological type studies have not defined their populations sufficiently to draw meaningful conclusions. A detailed study would include a specific medical diagnosis for all members of the study and specific details about the individual in the study samples (e.g., driving exposure, sex, driving environment, types of vehicles, driver training, etc.)

4. Validated procedures for the assessment and evaluation of each handicapped group. These procedures would be for:

    - Acceptance into a driver education program
    - Personal evaluation of capabilities for determining type of driver education needed
    - Licensing (full or conditional)
    - Re-licensing (after having been licensed previously)

5. Development of more specific medical criteria that are validated. These would be used as a basis for:
    - Determination if applicants are allowed to drive at all
    - Determination of type of conditional license
    - Period of time between license re-examination
6. Development of driver educational materials. These would be designed for use in public schools, rehabilitation institutions, private driving schools and others. The following are the types of educational packages that would be developed:
    - Curriculum materials for each of the various handicaps (e.g., materials for the mentally retarded, the epileptic, those with cardiovascular disease, the orthopedically impaired, etc.)
    - Training package to teach techniques to driver education personnel (both special education and driver training instructors)
    - Training package for school administrators so that teaching programs for the handicapped can be established
    - Different programs for the new driver, for remedial training, and for the newly handicapped driver
7. Development of educational materials and programs related to the licensing and education of handicapped drivers. These could take the form of complete programs, or simply, booklets. The following are the types of persons for whom these programs could be developed:
    - Specialists in the DMV (DLE, DIA, and others)
    - DMV administrators
    - Private physicians and public health people
    - Medical advisory board participants

- Court and legal personnel
- Police
- General public
- Handicapped themselves
- Legislative persons
- Motor vehicle inspectors
- Emergency medical personnel
- Special interest groups

8. Establishing and implementing an improved education and licensing system. This would include collecting data to evaluate and improve the system itself.

9. Establishing and running a clearinghouse for information on handicapped drivers. This clearinghouse would be a central repository for all the research fields that contribute to this area.

10. Study the potential effects of therapeutic drugs. This would be the development of a catalogue of available information on all therapeutic drugs and the possible effects on driving. This could also include experimentation to determine specific effects.

11. Studying the use of and establishing a conditional license program. The principal interests of the study would be the legal, implementation, enforcement, and cost implications of a useful conditional licensing program.

12. Development and validation of a driver performance test. A valid driver performance test could be used for both the able-bodied and the handicapped, alike.

VI. REFERENCES

Aaron, J. E. Driver education for the handicapped resource guide, Volume II. September, 1971, Southern Illinois University, Contract No. SEE 35-009-71, U.S. Department of Transportation.

Abt Associates, Inc. Transportation needs of the handicapped. August 1969, Contract No. T8-304, U.S. Department of Transportation.

Adserballe, M. Driving license and mental disease. *Ugeskrift for Laeger*, 1974, *136*(4), 215-222.

Allan, K. H., & Cinsky, M. E. General characteristics of the disabled population. *Social Security Bulletin*, 1972.

Allen, M. J. *Vision and highway safety*. New York: Chilton Book Company.

Altobelli, F. O. The handicapped as automobile drivers. *Rehabilitation Record*, 1964, *5*(6).

American Association of Motor Vehicle Administrators and the Committee on Motorists Vision and Highway Safety. *Vision screening for driver licensing*. St. Louis: American Optometric Association, 1966.

American Automobile Association. *Vehicle controls for disabled persons, (including wheel chairs, ramps, and lifters)*. Washington: American Automobile Association, 1972.

American Diabetes Association, Inc. *Facts about diabetes*. New York: American Diabetes Association, Inc., 1966.

American Jurisprudence, 2nd Series. 1970, *7*(106), 673-675.

American Law Reports, 3rd Series. 1971, *38*, 452-472.

American Medical Association, Committee on Medical Aspects of Automotive Safety. Determination of need for medical evaluation in driver licensing. *Journal of the American Medical Association*, 1968, *203*(10), 879-880.

American Medical Association. *Physicians guide for determining driver limitation*. Chicago: American Medical Association, 1968 and 1973.

American Medical Association, Journal of. Motivation helps drivers make up for physical handicaps. *Journal of the American Medical Association*, 1971, *215*(6).

American Medical Association & American Association of Motor Vehicle Administrators. *Medical orientation for driver examiners.* Washington: American Association of Motor Vehicle Administrators, 1973.

American Medical Association. *Proceedings on the national conference on the aging driver.* Morton Grove, Ill., 1974.

American Optometric Association & American Association of Motor Vehicle Administrators. *Vision: Its role in driver licensing.* St. Louis, Mo.: American Optometric Association, 1974.

Arthur D. Little, Inc. Employment, transportation and the handicapped. Final Report, July 1968, Contract No. RC-45-G-67-1, U.S. Department of Health, Education and Welfare. PB 208-344.

Arthur D. Little, Inc. *The state of the art of traffic safety.* New York: Praeger Publishers, 1970.

Backe, J. 31st annual meeting of the German Society for Traumatology, Insurance, Welfare and Traffic Medicine, Inc. *Deutsches Medizinisches Journal*, 1967, *18*(24), 736-739.

Bailey, T. Independence--mini style. *Nursing Mirror and Midwives Journal*, 1970, *131*(4), 37.

Baker, S. P., & Spitz, W. U. Age effects and autopsy evidence of disease in fatally injured drivers. *Journal of the American Medical Association*, 1970, *214*(6), 1079-1088.

Baker, S. P., & Spitz, W. U. An evaluation of the hazard created by natural death at the wheel. *New England Journal of Medicine*, 1970, *283*(8), 405-409.

Baldwin, R. W., Schoolman, L. R., Whittlesey, P., & Kinnamon, H. F. A symposium on medical conditions constituting a hazard in driving. *Maryland State Medical Journal*, 1966, *15*, 55-58.

Balkanyi, A. Various causes of disturbances of consciousness important for traffic medicine. *Praxis*, 1971, *60*(17), 532-534.

Bankes, J. L. Eye defects of mentally handicapped children. *British Medical Journal*, 1974, *2*(918), 533-535.

Banks, T. E. The role of physical disabilities. *Journal of the Louisiana State Medical Society*, 1967, *119*(9), 352-354.

Bardach, J. Psychological considerations in the driving skills of the handicapped person. Symposium presented at the American Psychological Association, Washington, D.C., September 1969.

Bardach, J. L. Psychological factors affecting driving behavior in the disabled. Medical Clinics of North America, 1969, 53(3), 692-695.

Bardach, J. L. Psychological factors in the handicapped driver. Archives of Physical Medicine and Rehabilitation, 1971, 52(7), 328-332.

Baroody, N. B. The car and the cardiac. American Family Physician, 2(6), 71-76.

Bartels, E. C., & Kusakcioglu, O. Narcolepsy: A possible cause of automobile accidents. Lahey Clinic Foundation Bulletin, 1965, 14, 21-26.

Personal Communication with L. Bartels, Iowa State Vocational Rehabilitation Center. Description of student disabilities, pre-screening and driver education procedures, September 9, 1975.

Bellet, S., Roman, L., Kostis, J., & Slater, A. Continuous electrocardiographic monitoring during automobile driving. American Journal of Cardiology, 1968, 22, 856-862.

Berger, J. E. Traffic accidents, fatal injuries, and psychiatry. Clinics in Plastic Surgery, 1975, 2(1), 3-10.

Berner, L. Driver training for the severely handicapped. American Corrective Therapy Journal, 1968, 22(1), 18-20.

Beskow, B. Driving licenses for mentally retarded? Lakartidningen, 1973, 70(13), 1309-1311.

Betts, T. A., Clayton, A. B., & Mackay, G. M. Effects of four commonly used tranquilizers on lowspeed driving performance tests. British Medical Journal, 1972, 4, 580-584.

Bishop, R. Questions and answers about driving simulators. Safety Education, Chicago, Illinois.

Bixler, E., Kales, A., Tjiauwling, T., & Kales, J. The effects of hypnotic drugs on performance. Current Therapeutic Research, 1973, 15(1), 13-24.

Blohmke, F. The amputee in road traffic. Hefte Unfallheilkd, 1973, 114, 238-242.

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Letter from M. Bloomer. Summary of screening, eligibility, evaluation and training procedures of the handicapped driver education department in the Oklahoma City Public Schools, September 19, 1975.

Bolinger, W. T. Project: students phase II, safety training using driver education non-traditional systems. Ohio, Montgomery County Public Schools, August 1970, Project 442C-MR-70, E.S.E.A. Title VI.

Bologa, J. F., Kettering, W. R., Mullin, R. C., & Strickler, D. J. The measurement and comparison of variables related to driver and highway safety between educable mentally retarded and normal high school age students in Pennsylvania. Final Report, February 1, 1971, Millersville State College, Grant No. OEG-0-9-48-2062-1326-(032), Department of Health, Education and Welfare, Office of Education. Eric No. ED 056 446.

Bonner, J., Gutshall, R., & Kenel, F. *Teaching materials for obtaining a permit*. Taken from *Basic driver education. Danville, Ill.:* Interstate Printers & Publishers, Inc.

Bonner, J., Gutshall, R., & Kenel, F. *Basic driver education--Teacher's manual*. Danville, Ill.: *Interstate Printers & Publishers, Inc.*, 1968.

Bourgeois, M. On the pathology of the driver's license. *Societe Medico-Psychologique*, 1969, (Seance du 24 Fevrier), 438-444.

Brandaleone, H. Medical factors. *New York State Journal of Medicine*, 1963, *63*(12), 1773-1783.

Brandaleone, H. Motor vehicle driving and cardiac pacemakers. *Annals of Internal Medicine*, 1974, *81*(4), 548-550.

Brandaleone, H., & Friedman, G. J. The medical aspects of motor vehicle accident prevention. *Annals of Internal Medicine*, 1958, *48*, 363-371.

Brandaleone, H., Katz, R., Tebrock, H. E., & Wheatley, G. M. Study of the relationship of health impairments and motor vehicle accidents. *Journal of Occupational Medicine*, 1972, *14*(11), 854-859.

Brandaleone, H., & Sim, R. Medical aspects of driver licensing. *New York State Journal of Medicine*, 1966, *66*(5), 602-608.

Bray, P., & Cunningham, D. M. Vehicles for the severely disabled. *Rehabilitation Literature*, 1967, *28*(4), 98-109.

Brazell, R. E. *A comparison of various behind-the-wheel training methods*. Michigan: The Safety and Traffic Division, 1962.

Briggs, G. Driving as skilled performance. In J. O'Day (Ed.), *Driver behavior: cause and effect*. Proceedings of the Second *Annual Traffic Safety Research Symposium* of the Automobile Insurance Industry, Highway Safety Research Institute, 1968. PB 211-047.

Brown, E. B. Driver education for the physically handicapped. *Journal of Traffic Safety Education*, 1975, *22*, 11.

Brown, I. D., & Poulton, E. C. *Ergonomics*, 1961, *5*, 35.

Brown, P. L., & Berdie, R. F. Driver behavior and scores on the MMPI. *Journal of Applied Psychology*, 1960, *44*(1), 18-21.

Personal Communication with J. E. Bryan, American Academy for Crebral Palsey. July 1975.

Burg, F. D., Stock, M. S., Light, W. O., & Douglass, J. M. Licensing the deaf driver. *Arch Otolaryng*, 1970, *91*(3), 289-290.

Buttiglieri, M. W., & Guennette, M. Driving records of neuropsychiatric patients. *Journal of Applied Psychology*, 1967, *51*(2), 96-100.

Buttiglieri, M. W., & Guennette, M. Temporal relationship between automobile accidents and psychiatric hospitalization. *Perceptual and Motor Skills*, 1967, *24*(3), 1327-1332.

Buttiglieri, M. W., Guennette, M., & Thomson, M. Driving record of medical and surgical patients. *Perceptual and Motor Skills*, 1969, *29*, 427-434.

California, State of, Los Angeles City Unified School District. Driver education course of study for EMR students. Los Angeles, California, 1970.

Campbell, O. F., & Ellis, K. G. Chronic medical conditions and traffic violation and accident experience of diabetic drivers. *Modern Medicine of Canada*, 1969, *24*(11), 29-31.

Canadian Medical Association, Committee on Emergency Services. *Guide for physicians in determining fitness to drive a motor vehicle*. Ottawa: Canadian Medical Association, 1974.

Canty, A. Problem drivers and criminal offenders: A diagnostic comparison. Behavior defects as a cause of traffic accidents, International Conference on Medical Aspects of Traffic Safety. Montreal: Sun Life Assurance Company, 1955.

Personal Communication with H. Champagne, American School for the Deaf. July 1975.

Cheetham, R. W. Road safety and mental health in South Africa, Part II. *South African Medical Journal*, 1974, *48*(6), 225-229.

Committee on Medical Rating of Physical Impairment. Guides to the evaluation of permanent impairment: The extremities and back. *Journal of the American Medical Association*, 1958, Special Edition, 1-106.

Committee on Medical Rating of Physical Impairment. Guides to the evaluation of permanent impairment: The cardiovascular system. *Journal of the American Medical Association*, 1960, *172*(10), 139-149.

Committee on Medical Rating of Physical Impairment. Guides to the evaluation of permanent impairment: Ear, nose, throat, and related structures. *Journal of the American Medical Association*, 1961, *177*(7), 99-111.

Committee on Medical Rating of Physical Impairment. Guides to the evaluation of permanent impairment: The central nervous system. *Journal of the American Medical Association*, 1963, *185*(1), 104-115.

Committee on Medical Rating of Mental and Physical Impairment. Guides to the evaluation of permanent impairment: The digestive system. *Journal of the American Medical Association*, 1964, *188*(2), 151-160.

Committee on Medical Rating of Mental and Physical Impairment. Guides to the evaluation of permanent impairment: The peripheral spinal nerves. *Journal of the American Medical Association*, 1964, *189*(2), 154-165.

Committee on Medical Rating of Mental and Physical Impairment. Guides to the evaluation of permanent impairment: The respiratory system. *Journal of the American Medical Association*, 1965, *194*(8), 177-187.

Committee on Medical Rating of Mental and Physical Impairment. Guides to the evaluation of permanent impairment: The endocrine system. *Journal of the American Medical Association*, 1966, *198*(2), 215-224.

Committee on Medical Rating of Mental and Physical Impairment. Guides to the evaluation of permanent impairment: Mental illness. *Journal of the American Medical Association*, 1966, *198*(12), 146-155.

Committee on Nomenclature and Statistics of the American Psychiatric Association. *Diagnostic and statistical manual of mental disorders*. Washington, D.C.: American Psychiatric Association, 1968.

Compact. State programs for the handicapped. *Compact*, 1971, 37-42.

Conference of Executives of American Schools for the Deaf, Inc., Captioned Films for the Deaf Distribution Center. *Catalog of captioned films for the deaf: (theatrical films and educational films for adults), Vol. II*. Washington, D.C.: U.S. Department of Health, Education and Welfare, Office of Education, Bureau of Education for the Handicapped, Captioned Films and Telecommunications Branch, 1974.

Conger, J. J., Gaskill, H. S., Glad, D. D., Hassel, L., Rainey, R. V., Sawrey, W. L., & Turrell, E. S. Psychological and psycho-physiological factors in motor vehicle accidents. *Journal of the American Medical Association*, 1959, *169*, 158.

Conger, J. J., Gaskill, H. S., Glad, D. D., Rainey, R. V., Sawrey, W. L., & Turrell, E. S. Personal and interpersonal factors in motor vehicle accidents. *American Journal of Psychiatry*, 1957, *113*, 1069-1074.

Conley, R. W. *The economics of vocational rehabilitation.* Baltimore: Johns Hopkins Press, 1965. ED015566.

Connecticut, State of, Motor Vehicle Department. *Some of our best drivers*. Hartford: State of Connecticut, 1970.

Coppin, R. S., & Peck, R. C. The totally deaf driver in California: Part I. Report Number 15, July 1963, Division of Administration, California Department of Motor Vehicles.

Coppin, R. S., & Peck, R. C. The totally deaf driver in California: Part II. Report Number 16, December 1964, Division of Administration, California Department of Motor Vehicles.

Corpus Juris Secundum, Updated through 1975. *60A*(264), 114-128.

Corpus Juris Secundum, Updated through 1975. *60*(147), 792-794.

Corpus Juris Secundum, Updated through 1975. *60*(154), 800-804.

Crancer, A., & McMurray, L. Accident and violation rates of Washington's medically restricted drivers. *Journal of the American Medical Association*, 1968, *205*(5), 74-78.

Crancer, A., & O'Neall, P. A record analysis of Washington drivers with license restrictions for heart disease. *Northwest Medicine*, 1970, *69*, 409-416.

Crancer, A., & Quiring, D. *Driving records of persons with selected chronic diseases.* Washington: State Department of Motor Vehicles, 1968.

Crancer, A., & Quiring, D. L. The mentally ill as motor vehicle operators. *American Journal of Psychiatry*, 1969, *126*(6), 75-81.

Cronic diseases and traffic safety. *British Medical Journal*, 1966, *2*(5504), 3-4.

Cunningham, D. The driving simulator--a better way to teach deaf drivers. *The Volta Review*, 1970, *72*(6), 372-375.

Cunningham, D. M. Special vehicles for the severely disabled. Special Report, 1971, University of California, Grant No. RD-2615-G, Department of Health, Education and Welfare, Social and Rehabilitative Service. PB 215-346.

Dallmeyer, K. E. Transportation mobility analysis of the handicapped. Research Report No. 14, 1974, Center for Urban Transportation Studies.

Dawson, W. W. Stereoscopic perceptual deficit of mentally retarded adults. *American Journal of Mental Deficiency*, 1967, 964-968.

DeBenedictis, J. A., & Dougherty, E. J. A directory of vehicles and related system components for the elderly and handicapped. Report No. UMTA-PA-06-0031-75-1, June, 1975, Franklin Institute Research Laboratories, U.S. Department of Transportation, Urban Mass Transportation Administration. PB 244-474.

DeLateur, B. J., Lehmann, J. F., Winterscheid, L. C., Wolf, J. A., Fordyce, W. W., & Simon, B. C. Rehabilitation of the patient after hemicorporectomy. *Archives of Physical Medicine and Rehabilitation*, 1969, *50*(1), 11-16.

Deyoe, F. S., & Andersen, V. W. Wheelchair-car transfers for quadriplegics. *American Corrective Therapy Journal*, 1970, *24*, 130-132.

Dick, H. F. Symposium: Driver education and the educable mentally handicapped. Symposium presented at the 49th Annual International CEC Convention, Miami Beach, Florida, April 1971.

Dick, H., & Gresham, L. Teaching the handicapped to drive. *Perception, Allstate Insurance Company*, 1974, *8*(4).

Diller, L., & Weinberg, J. Attention in brain-damaged patients. *Journal of Education*, 1968, *150*, 20-27.

DiMaio, D. J. A survey of sudden, unexpected deaths in automobile drivers. Presented at the Third Triennial Congress on Medical and Related Aspects of Motor Vehicle Accidents, New York, New York, May 29-June 1, 1969.

Dokert, B. Drugs, drug dependence and traffic safety. Psychophysical capacity under the influence of drugs and their effect on traffic. *Pharmazeutische Praxis*, 1970, *1*, 1-6.

Downard, M. E., Ohio Bureau of Motor Vehicles. Driver licensing. Presented at Symposium for the Handicapped Driver, Highland View Hospital, Cleveland, Ohio, 1973.

Dreyer, D. R. Physically handicapped drivers: a comparative study of driver records. Research Report 42. Sacramento, Calif.: Department of Motor Vehicles, 1973.

Driver Education Digest. Handicapped learn to drive in Skokie's special pilot course. *Driver Education Digest*, 1972-1973, *4*(4).

Driving School Association of America, Inc. Commercial sources of devices, controls, and modifications for the handicapped driver. Unpublished manuscript, Driving School Association of America, Inc., 1975.

Dwoskin, S. The disabled's encounter with the environment. *Design and Environment*, 1970, *1*(2), 60-63.

Edhag, O. Long term cardiac pacing: experience of fixed pacing with an endocardial electrode in 260 patients. *Acta Medica Scandinavica*, 1969, Supplementum 502, 88-89.

Educational Testing Service. Career education for the handicapped 1964-1974: Volume 1, 1975, Contract No. OEC-O-74-7366, U. S. Department of Health, Education and Welfare.

Educational Testing Service. Career education for the handicapped 1964-1974: Volume 2, 1975, Contract No. OEC-O-74-7366, U.S. Department of Transportation.

Eelkema, R. C., Brosseau, J., Koshnick, R., & McGee, C. A statistical study on the relationship between mental illness and traffic accidents. North Dakota University, 1968.

Eelkema, R. C., Brosseau, J., Koshnick, R., & McGee, C. A statistical study on the relationship between mental illness and traffic accidents--a pilot study. *American Journal of Public Health*, 1970, *60*(3), 459-469.

Egan, R. Should the educable mentally retarded receive driver education? *Exceptional Children*, 1967, *33*(5), 323.

Eisenlauer, R. A pilot program for teaching the handicapped to drive. *Perception*, 1974, *8*(4).

Letter from R. Eisenlauer and L. Rotschafer of the Des Moines, Iowa Public Schools. Summary of driver education program for the handicapped in Des Moines, Iowa, September 11, 1975.

Ellingstad, V. S. A multivariate evaluation of selected driver performance measures. University of South Dakota, Department of Psychology, Human Factors Laboratory, Vermillion, South Dakota, 1969.

Ellingstad, V. S. A factor analytic approach to the driving task. *Behavioral Research in Highway Safety*, 1970, *1*, 115-126.

Ellingstad, V. S. A driving task analysis. In Hiemstra, N. W. (Ed.), *Injury Control in Traffic Safety*. Springfield, Ill.: Charles C Thomas, 1970.

Emara, A. M. Problems in employment of diabetics in transport jobs. *Journal of the Egyptian Medical Association*, 1969, *52*, 677-688.

Engels, V. E. A comparison of driving ability of handicapped and able-bodied drivers. Unpublished masters thesis, University of Illinois, 1966.

Epilepsy Foundation of America. *Basic statistics on the epilepsies*. Washington, D.C., 1975.

Falconer, M. A., & Taylor, D. C. Driving after temporal lobectomy for epilepsey. *British Medical Journal*, 1967, *1*, 266-269.

Fergenson, P. E. The relationship between information processing and driving accident and violation record. *Human Factors*, 1971, *13*(2), 173-176.

Ferguson, D. Transport of handicapped persons by car. *Medical Journal of Australia*, 1974, *1*(23), 914-919.

Fine, B. J. Introversion-extraversion and motor vehicle driver behavior. *Perceptual and Motor Skills*, 1963, *12*, 95-100.

Finesilver, S. C. They can't hear but they get the message. U.S. Department of Health, Education and Welfare, Office of Vocational Rehabilitation, Washington, D.C.

Finesilver, S. C. A study on driving records, licensing requirements and insurability of physically impaired drivers. Final Report, October 1, 1970, Denver University, Grant No. SRS-RD-2283-G, U.S. Department of Health, Education and Welfare, Social Rehabilitation Service.

Letter from K. P. Fisher, Easter Seal Rehabilitation Center, New Haven, Connecticut. Summary of driver education program, August 14, 1975.

Florida, State of, Department of Motor Vehicles. *Study guide for use with the adapted Florida driver's handbook*. Salt Lake City: Effort, Inc.

Florida, State of, Department of Motor Vehilces. *Words to know in the adapted Florida driver's handbook*. Salt Lake City: Effort, Inc.

Florida, State of, Department of Motor Vehilces. *Adapted Florida driver's handbook*. Salt Lake City: Effort Publishing Corp., 1970.

Florio, A. E. Teacher training manual using simulators for teaching the physically handicapped. University of Illinois, Safety Education Section, 1971.

Foley, W. J., McGenn, M. E., & Lindenauer, S. M. Automobile drivers and cerebrovascular insufficiency. *Journal of the American Medical Association*, 1969, *207*(4), 749-751.

Fox, H. G. Drivers: Silent but skilled. *Police Chief*, January 1969.

Letter from M. D. Freels, Special School District of St. Louis County, Missouri, September 26, 1975.

Freeman, C. C. Evaluation of adaptive automotive driving aids for the disabled. *New York Academy of Medicine Bulletin*, 1974, *50*(4), 536-544.

Frieden, F. H., Gertter, M., Tosberg, W., & Rusk, H. A. Rehabilitation after hemicorporectomy. *Archives of Physical Medicine and Rehabilitation*, 1969, *50*(5), 259-263.

Frolich, P. *The 1967 national survey of institutionalized adults*. Washington, D.C.: U.S. Government Printing Office, 1974. Stock No. 1770-00244.

Frostig, M., & Horne, D. An approach to the treatment of children with learning difficulties. *Learning Disorders*, 1965, *1*, 293-305.

Gallagher, J. R., & Moore, R. C. Causes of accidents of adolescent drivers. *Journal of Traffic Safety*, 1969.

Gampel, J. Some aspects of the evaluation of degree of disability. *Israel Annals of Psychiatry and Related Disciplines*, 1974, *12*(4), 333-335.

Garrett, J., & Levine, E. *Psychological practices and the physically disabled*. New York: Columbia University Press, 1962.

Garris, A. G. Driving power important to disabled persons. *Journal of Rehabilitation*, 1973, *39*(6), 31-32.

Georgia, State of, Department of Public Safety. Drivers license advisory board guidelines. November 30, 1974.

Gerber, S. R., Joliet, P. V., & Feegel, J. R. Single vehicle accidents in Cuyahoga County: 1958-1963. *Journal of Forensic Science*, 1966, *11*, 144-151.

Gibbs, W. L. Driver gap acceptance at intersections. *Journal of Applied Psychology*, 1968, *52*(3), 200-204.

Gilder, S. Driver, disease, and traffic accidents. *World Medical Journal*, 1965, *12*, 142-143, 156-157.

Personal Communication with R. Glenn, Higbee's Driving School, Cleveland, Ohio, August 15, 1975.

Personal Communication with T. Goble, Eastern Kentucky Comprehensive Rehabilitation Center, Thelma, Kentucky, August 15, 1975.

Personal Communication with J. Goldberg, Architectural Barriers, Muscular Dystrophy Association, New York, August 1975.

Goldberg, M. J., & Davis, L. J. Method of lifting wheelchair into two-door sedan by a paraplegic patient. *Archives of Physical Medicine*, 1967, *48*, 615.

Goodwill, C. J. Powered vehicles and the disabled driver. Presented at the meeting of the Royal Society of Medicine, London, England, 1974. *British Medical Journal*, 1974, *67*, 416-419.

Grant, W. V., & Lind, C. G. *Digest of educational statistics*. Washington, D.C.: U.S. Government Printing Office, 1975. Stock No. 017-080-01393-4.

Grattan, E., & Jeffcoate, G. O. Medical factors and road accidents. *British Medical Journal*, 1968, *1*, 75-79.

Greenshields, B. D., & Platt, F. N. Development of a method of predicting high-accident and high-violation drivers. *Journal of Applied Psychology*, 1967, *51*(3), 205-210.

Gresham, L. The handicapped driver and his car. *Perception*, 1974, *8*(4).

Grimmond, B. B. Suicide at the wheel. *New Zealand Medical Journal*, 1974, *80*(521), 90-94.

Gutshall, R. The handicapped student and the automobile. *Traffic Safety*, 1962, 15-16.

Gutshall, R. W. An exploratory study of the interrelations among driving ability, driving exposure and socioeconomic status of low, average and high intelligence males. (Doctoral dissertation, Michigan State University). Xerox microfilm order number 67-10,525.

Gutshall, R. W., Harper, C., & Burke, D. An exploratory study of the interrelations among driving ability, driving exposure, and socioeconomic status of low, average, and high intelligence males. *Exceptional Children*, 1968, 43-47.

Haber, L. D. Identifying the disabled: concepts and methods in the measurement of disability. *Social Security Bulletin*, 1967.

Haber, L. D. Epidemiological factors in disability: I--Major disabling conditions. From the Social Security survey of the disabled, 1966. Report Number 6, 1969, U.S. Department of Health, Education and Welfare, Social Security Administration, Office of Research and Statistics.

Haber, L. The epidemiology of disability: II--The measurement of functional capacity limitations. Social Security survey of the disabled, 1966. Report Number 10, July 1970, U.S. Department of Health, Education and Welfare.

Haber, L. D. Disabling effects of chronic disease and impairment, II: Functional capacity limitations. *Journal of Chronic Diseases*, 1973, *26*(3), 127-151.

Personal Communication with K. Hall, National Center for Law and the Handicapped, July 10, 1975.

Hall, M. What kind of tricycle or car? *Design*, 1969, 34-35.

Hames, L. Clues that help spot medically impaired drivers. Traffic Safety, 1973, 9-10, 38-40.

Hames, L. N. Medical orientation for driver examiners. Presented at the 17th Annual Conference of American Association for Automobile Medicine, Oklahoma City, 1973.

Hames, L. N. The role of medical advisory boards in driver licensure. Speech delivered to the AAMVA, Regional Conference, Moncton, New Brunswick, Canada, 1973.

Hampel, B. Investigations relative to driving ability and intelligence. Psychologie und Praxis, January-March 1962, Heft 1.

Harano, R. M., Peck, R. C., & McBride, R. S. The prediction of accident liability through biographical data and psychometric tests. Journal of Safety Research, 1975, 7(1), 16-52.

Harden, D. H., & Tenniswood, D. M. Advanced concepts in automobile driver controls. Paper presented at the Automobile Engineering Meeting, Detroit, May 1973. Number 730472.

Harrington, D. M. The young driver follow-up study: An evaluation of the role of human factors in the first four years of driving. Final Report, 1971, California State Department of Motor Vehicles, Contract No. HPR-PR-1(7)B0013, U.S. Department of Transportation, Federal Highway Administration.

Personal Communication with T. Harrison, Inspector, Connecticut State Driver Training Program for the Handicapped, Hartford, Connecticut, July 1975.

Hartmann, H. Sudden death at the wheel. Postgraduate Medicine, 39, A-68-A-76.

Hartmann, H. Cardiac and circulatory patients as traffic risks. Helvatica Medica Acta, 1965, 32(135), 135-154.

Hartmann, H. The medical evaluation of physically handicapped automobile drivers on the basis of the legal regulations. Praxis, 1971, 60(17), 529-531.

Hay, R. Sudden illness and chronic disability in drivers as causes of road accidents: The present position. Manitoba Medical Review, 1968, 48, 159-161.

Hazen, T. D. A driving desire. California Journal.

Heinz, N., Scheppokat, K. D., & Kalmar, P. Pacemaker patients in traffic. Hefte Zur Unfallheilkunde, 1969, May 19-21, 251-259.

Heipertz, W. The severely disabled in the road traffic. Hefte Unfallheilkd, 1973, 114, 323-238.

Heimstra, N. W. (Ed.) Injury control in traffic safety. Springfield, Ill.: Charles C Thomas, 1970.

Helander, M. G. Physiological reactions of drivers as indicators of road traffic demand. Driver performance studies, (530), Transportation Research Board, National Research Council, Washington, D.C., 1975.

Henderson, R., & Burg, A. The role of vision and audition in truck and bus driving. December 1973, System Development Corporation, TM(L)-5260/000/00.

Henderson, R. L., & Burg, A. Vision and audition in driving. Final Report, November 1974, System Development Corporation, Contract No. DOT-HS-009-1-009, U.S. Department of Transportation, National Highway Traffic Safety Administration.

Henderson, H. L., & Kole, T. The automobile as a prosthetic device in physical rehabilitation. Journal of Rehabilitation, 1965, 31(3), 30-31.

Personal Communication with C. Hensel, California Safety Center, Montebelio, California, August 15, 1975.

Henshaw, J. T. A car to chair lift: Design of a prototype. Biomedical Engineering, 1970, 5, 398-400.

Herner, B. The effect of diseases and disabilities on traffic safety. Institute of Orthopaedics and Traumatology, University of Rome. In Proceedings of the Second Congress of the International Association for Accident and Traffic Medicine, 1966, Sweden, Pg. 112-124. NTIS m.f. No. HS 003-499.

Herner, B., Sendby, B., & Ysander, L. Sudden illness as a cause of motor-vehicle accidents. British Journal of Industrial Medicine, 1966, 23, 37-41.

Herner, B., & Ysander, L. Road safety and chronic disease. Suenska Lakartidningen, 1962, 59, 125.

Hierons, R. The epileptic driver. British Medical Journal, 1956, 1, 206-207.

Highway Safety Research Center. Are narrow visual fields related to accident involvement? Highway Safety Highlights, 1975, 8(10), 2.

Hoffmann, H. Cardiacs at the wheel of motor vehicles. *Munchener Medizinische Wochenschrift*, 1963, *105*, 1790-1796.

Hoffmann, H. Myocardial infarcts behind the wheel. *Munchener Medizinische Wochenschrift*, 1963, *105*, 1785-1789.

Hoffmann, H. The risks for healthy and for somatically diseased persons to take part in road traffic and, vice versa, the risks to the traffic by the participation of diseased persons: Prophylactic measures. *Clinic of Medicine*, 1966.

Hofkosh, J. Organizing and administering a program of driver education for the handicapped. Symposium presented at the American Psychological Association, Washington, D.C., September 1969.

Hofkosh, J. Driver education assessment and training programs. *Progress in Physical Therapy*, 1970, *1*(1), 75-86.

Hofkosh, J. M., Sipajlo, J., & Brody, L. Driver education for the physically disabled. *Medical Clinics of North America*, 1969, *53*(3), 685-689.

Hossack, D. Death at the wheel: a consideration of cardiovascular disease as a contributory factor to road accidents. *The Medical Journal of Australia*, 1974, *1*(6), 164-166.

Howe, L. E. A comparison of motor skills of mentally retarded and normal children. *Journal of Exceptional Children*, 1959, 352-354.

Huddleston, L. O., Moore, R. W., Garris, A. G., Kope, D., & Enns, C. Foot control driving apparatus for patients having little or no function in the upper extremities. *Archives of Physical Medicine and Rehabilitation*, 1957, 500-504.

Hughes, D. T. D., Cramer, F., & Knight, G. J. Use of a racing car simulator for medical research: The effects of marzine and alcohol on driving performance. *Medicine, Science, and the Law*, 1967, *7*, 200-204.

Human Resources Center, Abilities, Inc. Disability classifications. Unpublished.

Human Resources Center, Human Resources School. Disability classifications. Albertson, N.Y.: Human Resources Center, unpublished.

Human Resources Research Organization. Driver education curriculums for secondary schools--user guidelines. Final Report, September 1974, Contract No. DOT-HS-003-2-427, U.S. Department of Transportation, National Highway Traffic Safety Administration.

Hummel, G. R. A comparison of accelerator release and brake response times of ten hand and foot braking methods on a simulator under three experimental conditions. Unpublished masters thesis, University of Illinois, 1966.

Hussmann, W. Criteria for the judgment of the driving safety of a car driver. *Schweizerische Zeitschrift fur Psychologie und ihre Anwendungen*, 1967, Supplement, *51*, 86-113.

Hyman, W. A., Mayyasi, A. M., & Mann, C. F. Vehicle driving by the disabled: literature review. 1972, Texas A&M University, Contract No. V101(134).

Hyman, W. A., & Newell, P. H., Jr. An evaluation of several commercially available automotive hand controls. 1973, Texas A&M University, Contract No. V101(134), Veterans Administration, Washington, D.C.

Hymen, M. L. Hand-control drivers: comparison of driving records and insurance rates with those of nonrestricted drivers. *Archives of Physical Medicine and Rehabilitation*, 1974, *55*(10), 443-447.

Illinois, State of. Basic steering control classroom and in-car lesson. Unpublished manuscript.

Illinois, State of. Follow-up of driving records for educable mentally handicapped students, 11-14-73 to 11-13-74. Unpublished manuscript.

Illinois, State of. *Guidelines, forms and work procedures. Unit 1, Restrictions in drivers license application information.*

Illinois, State of, Office of the Superintendent of Public Instruction. Follow-up of driving records for socially maladjusted students, 11-14-73 to 11-13-74. Unpublished manuscript.

Illinois State University. Illinois demonstration center project: curriculum modules.

Imrie, J. Medical standards of fitness for driving. *The Practitioner*, 1962, *188*, 508-514.

Industrial Medical Association, Committee Report. Medical evaluation of the commercial-vehicle driver, a guide for the industrial physician. Journal of Occupational Medicine, 1966, 8(5), 274-279.

Jackson, P. Traffic accidents--back on the road. Canadian Journal of Occupational Therapy, 1969, 36, 61-64.

Letter from A. E. Johnson, Illinois Office of Education, Springfield, Illinois, September 12, 1975.

Johnson, L., & Lauer, A. R. A study of the effects of induced manual handicaps on automotive performance in relation to reaction time. Journal of Applied Psychology, 1937, 21, 85-93.

Kahn, C. H. Teaching driver education to mentally retarded adolescents. Exceptional Children, 1955, 17-19.

Kay, H. W., & Newman, J. D. Amputee survey, 1973-74: Preliminary findings and comparisons. Orthotics and Prosthetics, 1974, 28(2), 33-48.

Kay, H. W., & Newman, J. D. Relative incidences of new amputations: statistical comparisons of 6,000 new amputees. Orthotics and Prosthetics, 1975, 29(2), 3-16.

Keane, J. R. Automobile accidents caused by unsuspected neurological disease. Journal of Neurosurgery, 1973, 38, 581-583.

Keller, W. K., & Hames, L. N. Highway accidents: a medical-emotional problem. Medical Insight, 1973, 5(6), 26-31.

Kellerman, J. J., Kariv, I., Lederman, D., Wortreich, B., & King, B. G. Evaluation of cardiac patients with ischemic heart disease for motor vehicle driving. Presented at the Fifteenth Conference of the American Association for Automobile Medicine, Colorado Springs, Colorado, October 1971.

Kentucky State Medical Association, Highway Safety Committee. Kentucky program on medical aspects of driver limitation. The Journal of the Kentucky Medical Association, 1964, 62, 382.

Kenyon, R. The medical aspects of safe driving. Applied Therapeutics, 1970, 12(6), 15-18.

Kerrick, J. C. Who is fit to drive. Traffic Safety, 1965, 22-37.

Kesterson, V. Driver training provides self-help for the handicapped. *Perception*, 1974, *8*(4).

Personal Communication with V. Kesterson, Hot Springs Rehabilitation Center, Hot Springs, Arkansas, August 1975.

Kielholz, P., & Hobi, V. Effect of psychopharmacologic agents on driving ability. *Therapeutische Umschau/Revue Therapeutique*, 1974, *31*(9), 606-613.

Kimball, K. A., Ellingstad, V. S., & Hagen, R. E. Effects of experience on patterns of driving skill. *Journal of Safety Research*, 1971, *3*(3), 129-135.

Klein, D., & Waller, J. A. Causation, culpability and deterrence in highway crashes. 1960, Michigan State University and University of Vermont, U.S. Department of Transportation. Government Printing Office No. 1970 0-397-944.

Kirk, S. *Educating exceptional children*. Houghton Mifflin Co., 1972.

Koschlig, G. New medical guidelines for evaluating the driving ability of persons afflicted with nervous diseases and mental disorders. *Psychiatrie, Neurologie, und Medizinische Psychologie*, 1974, *26*(10), 606-616.

Krusen, F. H., Kottke, F., & Ellwood, P. M., Jr. (Eds.) *Handbook of physical medicine and rehabilitation*. Philadelphia: W. B. Saunders Co., 1965.

Kubacko, J. H., & Kokaska, C. J. Driver education for the educable mentally retarded: Is our instruction adequate? *Training School Bulletin*, 1969, *66*(3), 111-114.

Kuhl, V., Kiorboe, E., & Lund, M. The prognosis of epilepsy with special reference to traffic security. *Epilepsia*, 1967, *8*(3), 195-209.

Kunkel, E. Estimations of the relative danger of different traffic offenses. *Zeitschrift fur Experimentelle und Angewandte Psychologie*, 1966, *13*(4), 581-595.

Landauer, A. A., Milner, G., & Patman, J. Alcohol and amitriptyline effects on skills related to driving behavior. *Science*, 1969, *163*, 1467-1468.

Letter from J. Latimer, Gracewood State School and Hospital, Gracewood, Georgia, October 27, 1975.

Lauder, R. The goal is mobility: Environmental and transportation barriers encountered by the disabled. Presented at the National Citizens Conference on Rehabilitation of the Disabled and Disadvantaged, Washington, D.C., 1969. ED 044504.

Laurie, J. Vans, lifts, and hand controls. *Rehabilitation Gazette*, 1973, *16*, 8-10.

Layton, B. L. Individualized driver education: curriculum guide. Alabama State Department of Education, Office of Highway and Traffic Safety.

Layton, B. L. Driver education individualized--Alabama style. *Journal of Traffic Safety Education*, 1974, *21*(2), 17-18.

LeBlanc, M. A. Patient population and other estimates of prosthetics and orthotics in the U.S.A. *Patient Population*, 1973, 38-44.

Lehneis, H. R. The safety achievements of the disabled driver. *Bio-Medical Engineering*, 1973, *8*(10), 438-439.

Lehneis, H. R., Hofkosh, J. M., Sipajlo, J., & Wilson, R. G., Jr. Driving aids: design and development. *Medical Clinics of North America*, 1969, *53*(3), 689-692.

Lerner, P. R. *Social security disability applicant statistics/ 1969*. Washington, D.C.: U.S. Government Printing Office, 1973.

Lerner, P. R. *Social security disability applicant statistics/ 1970*. Washington, D.C.: U.S. Government Printing Office, 1974.

Less, M., & Manus, G. Policies and procedures in testing and licensing the disabled driver. Human Resources Center, New York State Department of Motor Vehicles, 1973.

Levin, H. S. Motor impersistence and proprioleptive feedback in patients with unilateral crebral disease. *Neurology*, 1973, *23*(8), 833-841.

Levy, R. L., DeLaChapelle, C. E., & Richards, D. W. Heart disease in drivers of public motor vehicles as a cause of highway accidents. *Journal of the American Medical Association*, 1963, *184*(6), 143-146.

Lewrenz, H. Principles and scale of automobile driver tests. *Hefte Unfallheilkd*, 1968, *94*, 232-242.

Linnoila, M. Drug effects on psychomotor skills related to driving: interaction of atropine, glycopyrrhonium and alcohol. *European Journal of Clinical Pharmacology*, 1973, *6*(2), 107-112.

Linnoila, M. Drug interaction on psychomotor skills related to driving: hypnotics and alcohol. *Annales Medicinae Experimentalis et Biologiae Fenniae*, 1973, *51*, 118-124.

Linnoila, M. Effects of antihistamines, chlormezanone, and alcohol on psychomotor skills related to driving. *European Journal of Clinical Pharmacology*, 1973, *5*(4), 247-254.

Linnoila, M. Effects of diazepam, chlordiazepoxide, thioridazine, haloperidole, flupenthixole, and alcohol on psychomotor skills related to driving. *Annales Medicinae Experimentalis et Biologiae Fenniae*, 1973, *51*, 125-132.

Linnoila, M. Effect of drugs and alcohol on psychomotor skills related to driving. *Annals of Clinical Research*, 1974, *6*, 7-18.

Linnoila, M., & Mattila, M. Drug interaction on psychomotor skills related to driving: diazepam and alcohol. *European Journal of Clinical Pharmacology*, 1973, *5*(3), 186-194.

Little, A. B., & Williams, G. J. Driver education for the educable mentally retarded. *New York State Education*, 1966, 12, 31.

Littler, W. A., Honour, A. J., & Sleight, P. Direct arterial pressure and electrocardiogram during motor car driving. *British Medical Journal*, 1973, *2*(861), 273-277.

Long, C. The handicapped driver--a national symposium. *Journal of Rehabilitation*, 1974, *40*(2), 34-39.

Lorman, A. J. Drugs, driving and the law: A report to the Governor and general assembly of Virginia. Charlottesville, Va.: Virginia Highway Research Council, October 1973.

Lowman, E., & Klinger. *Aids to independent living*. New York: McGraw-Hill Publishing Co., 1970.

Personal Communication with L. Lucpiliatreault, Rehabilitation Institute of Montreal and Canadian Paraplegic Association, Montreal, Quebec, Canada, July 3, 1975.

Maas, R. B. Safety tips for the hearing handicapped driver and worker. *The Belltone Magazine*, 1968, 11-13.

MacDonald, J. Suicide and homicide by automobile. *American Journal of Psychiatry*, 1964, *121*, 366-370.

Mach, J. Driving ability of the handicapped. Beitrage zur Orthopadie und Traumatologie, 1971, 18(3), 167-171.

Mackie, R. P. Special education in the United States, statistics 1948-1966. New York: Columbia University, Teachers College Press, 1969. ED 028564.

Maier, R. E. A comparison and projection of accident prevalence between educable mentally retarded and intellectually normal high school students in Pennsylvania. Unpublished masters thesis, Millersville State College, 1968.

Malfetti, J. L. The impaired driver. New York State Journal of Medicine, 1963, 1778.

Manus, G., & Less, M. Feasibility study on transportation for the handicapped. 1972, Human Resources Center, Inc., U.S. Department of Health, Education and Welfare, Bureau of Education for the handicapped.

Mark Battle & Associates, Inc. Transportation for the elderly and handicapped. Final Report, July 1973, Contract No. DC-06-0020, U.S. Department of Transportation, Urban Mass Transportation Administration. PB 225-285.

Personal Communication with Dr. W. A. Markel, American Cancer Society, New York, July 9, 1975.

Match, E., & Miller, A. W. Two driver education programs for the physically and mentally handicapped. Exceptional Children, 1969, 35(7), 563-564.

Mathias, J. D. Driver training. Rehabilitation Record, 1972, 13(4), 18-19.

Maxwell, R. D. H., & Leiphon, G. E. Epilepsy and driving. British Medical Journal, 1971, 3, 12-15.

Mayyasi, A. M., Pulley, P. E., Hyman, W. A., & Swarts, A. E. Categorization of disabilities and functional limitations imposed in the driving task. Presented at the Society of Automotive Engineers, Detroit, May 1973.

Mayyasi, A. M., Pulley, P. E., & Swarts, A. E. Complete single-footed automobile controller. Presented at the Society of Automotive Engineers, Detroit, May 1973.

McBride, R. S., & Stroad, K. W., Jr. Diagnostic assessment of driver problems: Vols. I and II. Final Report, June 28, 1974 and August 31, 1975, Human Resources Research Organization, Contract No. DOT-HS-4-01015, U.S. Department of Transportation, National Highway Traffic Safety Administration.

McCullough, N. C., Fryer, C. M., & Glancy, J. A new approach to patient analysis for orthotic prescription. Artificial Limbs, 1970, 14(2), 68-80.

McCue, B. J. Effects of driver simulation training on severely physically handicapped driver education students. Unpublished masters thesis, University of Illinois, 1971.

McCune, J. W. Including driver education in the special class curriculum. Teaching Exceptional Children, 1970, 2(3), 106-112.

McDermott, M., Newell, P. H., & Leavitt, L. A. Safety during mobility. Bulletin of Prosthetics Research, 1974 Research Issue, Research Center for Prosthetics, Department of Medicine and Surgery, Veterans Administration, 388-390.

McFarland, R. A., Domey, R. G., Duggar, B. C., Crowley, T. J., & Stoudt, H. W. An evaluation of the ability of amputees to operate highway transport equipment. General summary of Final Report RD-592. Harvard School of Public Health, 1968, Vocational Rehabilitation Administration.

McLane, R. C., & Wierwille, W. W. The influence of motion and audio cues on driver performance in an automobile simulator. Human Factors, 1975, 17(5), 488-501.

McPherson, K., & Kenel, F. C. Perception of traffic hazards: a comparative study. Traffic Safety Research Review, 1968, 46-49.

McPherson, K., & O'Leary, P. Driver education for educable mentally retarded students. Safety, 1969 (March-April), 18-21.

Metz, A. S. Number of pupils with handicaps in local public schools. Spring 1970, National Center for Educational Statistics, Report No. DHEW-OE-73-11107, 1973. ED 079897.

Michigan Department of Education. Report of a driver education/special education workshop. Presented at Central Michigan University, 1968.

Michigan Driver and Traffic Safety Education Department, Pontiac School District. A three year report of a multi-phase school and community traffic safety program. 1973, U.S. Department of Transportation, National Highway Traffic Safety Administration.

Mihevc, D. J. A comparison between response times of manual braking techniques and between manual braking and the conventional right foot braking method. Unpublished masters thesis, University of Illinois, 1965.

Miller, J. G. Objective measurements of the effects of drugs on driver behavior. Journal of the American Medical Association, 1962, 179, 940-943.

Miller, L., & Dimling, J. A., Jr. Driver licensing and performance, Volumes I, II, and III. Report 224, October 1, 1968, Spindletop Research, Inc., Contract No. FH-11-6533, U.S. Department of Transportation, National Highway Safety Bureau. PB 183-527, PB 187-528, PB 187-529.

Mirkin, A. Medical conditions and driving ability. Maryland State Medical Journal, 1967, 16, 54, 59-62.

Personal Communication with W. Misner, Johnstown Rehabilitation Center, Johnstown, Pennsylvania, July 30, 1975.

Mitchell, H. H. Medical problems and physical fitness as related to occurrence of traffic accidents. April 1968, The Rand Corporation, Contract No. FH-11-6698, U.S. Department of Transportation.

Mitchell, J., Feeney, R. J., & Corney, G. Car controls for the disabled--an analysis of the problems and indications for their solutions. University of Technology, Loughborough, Leicestershire, July 1975.

Mozes, M., Bank, H., & Wortreich, B. Subclavian steal syndrome and motor vehicle accidents. Lancet, 1967, 2, 533-534.

Mullin, R. A guide for the preparation of teachers of driver education. Millersville State College, Millersville, Pennsylvania, Unpublished.

Mullin, R. A program in driver education for medical education students. Millersville State College, Millersville, Pennsylvania, Unpublished.

Mundy, A. 1974 driver license administration requirements and fees. U.S. Department of Transportation, February 1974.

Personal Communication with Dr. E. F. Murphy, Director, Research Center for Prosthetics, Veterans Administration, New York, New York, October 6, 1975.

Myerburg, R. J., & Davis, J. H. The medical ecology of public safety: I, Sudden death due to coronary heart disease. American Heart Journal, 1964, 68, 586-595.

Nagi, S. Z. Some conceptual issues in disability and rehabilitation. In M. B. Sussman (Ed.) Sociology and rehabilitation, Washington, D. C.: American Sociological Association, 1965.

Nagi, S. Z. Disability and rehabilitation: legal, clinical, and self-concepts, and measurement. Columbus, Ohio: Ohio University Press, 1969.

Nagi, S. Z. An epidemiology of disability among adults in the United States. (Limited Distribution) 1975.

National Committee on Uniform Traffic Laws and Ordinances. *Driver licensing laws annotated.* Charlottesville, Va.: The Michie Company, 1974.

National Institute for Rehabilitation Engineering. Driving and the handicapped: all types of handicaps, hearing and vision requirements for driving, quadriplegics, equipping and training hearing or vision impaired to drive safely, the retarded. Topics in visual perception and industrial psychology. Pompton Lakes, N. J.: National Institute for Rehabilitation Engineering, 1974.

Neenan, W. B. Benefit-cost analysis and the evaluation of mental retardation programs. Washington, D.C., Urban Institute, 1973. ED 075960.

Neil, W. H. Influence of drugs on driving. *Texas State Journal of Medicine*, 1962, *58*, 92-97.

Nemarich, S. P., & Velleman, R. A. The modification of educational equipment and curriculum for maximum utilization by physically disabled persons; curriculum and instructional techniques for physically disabled students. Human Resources Study Number 12, 1969, Grant No. 2644, U.S. Department of Health, Education and Welfare, Office of Education. Eric No. ED 031 848.

Newell, P. A., Jr., Hyman, W. A., Krouskop, T. A., & McDermott, M., Jr. Mobility aids for the spinal cord injury patient. Report No. SAE 730471, 1973, Texas A&M University, Contract No. V101(134-P-17), Veterans Administration, Washington, D.C.

Newill, B. H. An analysis of Pennsylvania driver education programs for the educable mentally retarded. Unpublished masters thesis, Millersville State College, 1968.

New South Wales, Department of Motor Transport. *Human factors in traffic safety: a reappraisal.* New South Wales: Department of Motor Transport, 1971.

New York Heart Association (Ed.) *Diseases of the heart and blood vessels: nomenclature and criteria for diagnosis.* (7th ed.) Boston: Little, Brown & Company, 1973.

Nichols, J. L. Drug use and highway safety: a review of the literature. Final Report, July 1971, Wisconsin State University, Contract No. DOT-HS-012-1-019, U.S. Department of Transportation, National Highway Traffic Safety Administration.

Norman, L. G. Medical aspects of road safety. *Lancet*, 1960, *1*, 1038-1045.

Norman, L. G. Road traffic accidents: epidemiology, control, and prevention. Public Health Papers No. 13, World Health Organization, Geneva, 1962.

Nova Scotia Medical Society, The Committee on Traffic Accidents. Nova Scotia guide for physicians in determining fitness to drive a motor vehicle. *The Nova Scotia Medical Bulletin*, May 1966, 3-12.

Nussbaum, K. Psychiatric disability determination under Social Security in the United States. *Psychiatric Quarterly*, 1974, *48*(1), 65-73.

Personal Communication with T. Oakland, American Safety Association, Ted Oakland System of Driver Training, Akron, Ohio, July 1975.

Personal Communication with C. Odhner, Good Shepherd Rehabilitation Hospital, Allentown, Pennsylvania, August 15, 1975.

Oellerich, D. W., & Latimer, J. L. Are you teaching mentally retarded to drive? *Perception*, 1972, *6*(2).

Oklahoma State University, Southwest Center for Safety. *Proceedings of workshop: Steps for teaching the handicapped to drive*. Stillwater, Oklahoma, July 20-24, 1970.

Pappanikow, A. J., & Bowan, P. W. Driver education, asset or liability. *American Journal of Mental Deficiency*, 1959, 662-666.

Pappanikow, A. J., & Bowan, P. W. First results of a residential school driver education program. *American Journal of Mental Deficiency*, 1960, 194-198.

Perrine, M. W. Alcohol, drugs, and driving. Final Report, March 1974, Psychological Research Foundation of Vermont, Inc., Contract No. DOT-HS-265-2-439, U.S. Department of Transportation, National Highway Traffic Safety Administration.

Perry, C. J. G., & Morgenstern, A. L. Drugs and driving. *Journal of the American Medical Association*, 1966, *195*(5), 132-135.

Peters, J. J. Adaptive automotive controls. Presented at Symposium for the Handicapped Driver, Highland View Hospital, Cleveland, Ohio, 1973.

Peterson, B. J., & Petty, C. S. Sudden natural death among automobile drivers. Journal of Forensic Science, 1962, 7, 274-285.

Personal Communication with E. Petrucelli, Assistant for Safety Education, American Medical Association, October 8, 1975.

Phemister, J. C. Epilepsy and car-driving. Lancet, 1961, 1276-1277.

Phillips, B. K., & Holden, R. H. Relationship between fine manipulative ability and intelligence in adults in a vocational rehabilitation setting. Vocational Guidance Quarterly, 1967, 15(3), 213-216.

Pierron, R. N. Screening for driver limitation: review manual. Washington, D.C.: American Medical Association and American Association of Motor Vehicle Administrators, 1973.

Pinchard, M., & Rank, K. M. The handicapped behind the wheel--a survey of driving requirements for the handicapped.

Pizzette, M., & Bonaecorsi, S. Biomechanic considerations on the behavior of the lower right limb during driving of motor vehicles. Institute of Orthopaedics and Traumatology, University of Rome. In Proceedings of the Second Congress of the International Association for Accident and Traffic Medicine, 1966, Sweden, Pg. 169.

Pond, D. A., & Bidwell, B. H. Epilepsia, 1960, 1, 285.

Poor, C. R. Driver evaluation and training in a comprehensive rehabilitation center. Scandinavian Journal of Rehabilitative Medicine, 4(4), 182-187.

Porterfield, A. L. Traffic fatalities, suicide, and homocide. American Sociological Review, 1960, 25, 897-901.

Posner, M. I. Science, 1966, 152, 1966.

President's Committee on Employment of the Handicapped. In the driver's seat. Performance, 1974, 25(2), 15-16.

President's Committee on Mental Retardation. Transportation and the mentally retarded. National Center for Educational Research and Development, 1972. ED 064841.

President's Task Force on the Physically Handicapped. A national effort for the physically handicapped: The report. Washington, D.C.: U.S. Government Printing Office, 1970.

Letter from J. H. Quarles, Captain, Department of Public Safety, Atlanta, Georgia, September 9, 1975.

Quebec Ministry of Transport. *Medical guide to determine ability to drive a motor vehicle.* Department of Transport, July 1973.

Quensel, W. P. Plans for a more effective driver education curriculum. *Perception*, 1975, *8*(8).

Raffle, P. Medical examinations for public safety. *British Journal of Industrial Medicine*, 1959, *16*, 98-103.

Raffle, P. Fit to drive? *Health Trends*, 1971, *3*, 22-24.

Raffle, P. (Ed.) *Medical aspects of fitness to drive a motor vehicle: A guide for medical practitioners, Report of the medical commission on accident prevention.* London: Royal College of Surgery of England, 1971.

Personal Communication with W. E. Ramsey, West Virginia Rehabilitation Center, Institute, West Virginia, August 19, 1975.

Ransford, P. M. Medical conditions (physical) affecting driver behavior. Proceedings of Conference on Medical, Human and Related Factors Causing Traffic Accidents, including Alcohol, and other drugs. Montreal, 1972.

Rehabilitation Record. The long journey back. *Rehabilitation Record*, 1972, *13*, 20-21.

Reichenberger, A. J. Licensed Motor Vehicles for Handicapped Drivers, in Mobilizing for Spinal-cord-impaired people. Report of a Workshop, February 22-24, 1974, National Academy of Sciences, 1975.

Rektor, L. Psychiatric evaluation of the ability to drive motor vehicles. *Ceskoslovenska Psychologie*, 1969, *65*(2), 108-114.

Reynolds, J. Pre-driving orientation. Unpublished manuscript, Los Angeles Unified School District, Special Education Division.

Reynolds, J. A study to demonstrate the practicability and methodology of teaching driving to the physically disabled high school student. Final Report, 1968, Grant RD 1852-G, U.S. Department of Health, Education and Welfare.

Letter from J. Reynolds, Johns Hopkins Hospital, Baltimore, Maryland, September 10, 1975.

Rhoads, M. D. Filling the needs of the handicapped driver. *Traffic Safety*, 1974, 26-27, 35-37.

Richter, R. L., & Hyman, W. A. Research note: driver's brake reaction times with adaptive controls. Human Factors, 1974, 16(1), 87-88.

Ritter, G., & Ritzel, G. Examinations of traffic offenses of epileptics. Munchener Medizinische Wochenschrift, 1972, 114(47), 2077-2081.

Rogers, J. E. Adaptive devices for automobiles. Journal of Traffic Safety Education, 1975, 22(2), 9-10, 18.

Letter from A. S. Rose, Department of Neurology, University of California, September 26, 1975.

Personal Communication with J. Rossi, E-Z Train Driving School, Meriden, Connecticut, July 1975.

Roydhouse, N. Deafness and driving. New Zealand Medical Journal, 1967, 66, 878-881.

Rozin, R., & Tolnai, D. Car independence for patient with triplegia. Archives of Physical Medicine and Rehabilitation, 1971, 52(2), 80-81.

Reusch, J., Sabine, J., Peterson, H. W., & Inbeau, S. Measurement of social disability. Comprehensive Psychiatry, 1972, 13(6), 507-518.

Sanders, D. G. An aid for disabled drivers--a powered hoist for wheelchair stowage. Biomedical Engineering, 1974, 9(9), 431-432.

Savage, P. P., & Wilkinson, V. Reaction time in psychiatric patients: pilot study. New Zealand Medical Journal, 1971, 73(468), 285-288.

Schein, J. D. The deaf driver, the deaf community study of metropolitan Washington, D.C. U.S. Department of Health, Education and Welfare, Vocational Rehabilitation Administration.

Schein, J. D. The deaf community. Washington, D.C.: Galludet College Press, 1968.

Schori, T. R. Experimental approaches and hardware for driving research. In Heimstra, N. W. (Ed.) Injury control in traffic safety. Springfield, Ill.: Charles C Thomas, 1970.

Schlesinger, L. E. Objectives, methods, and criterion tests in driver training. Traffic Safety Research Review, 1967, 11, 18-24.

Schlesinger, L. W., & Safren, M. A. Perceptual analysis of the driving task. *Highway Research Record*, 1963, *84*, 54-61.

Schumann, H. J. von. Re-issuance of a driver's license after psychotherapy. *Allgemeinmed*, 1972, *48*(28), 1290-1298.

Schweikert, H. A. *Mobility needs for physically impaired persons.* Washington, D.C.: Paralyzed Veterans of America, Inc., 1969.

Scott, C. M. Driver safety in modified vans. *Bulletin of Prosthetics Research*, 1974, Research Conference Issue, Research Center for Prosthetics, Department of Medicine and Surgery, Veterans Administration, 377-387, 1974.

Personal Communication with D. Selwyn, National Institute for Rehabilitation Engineering, Pompton Lakes, New Jersey, September 16, 1975.

Selzer, M. L. Alcoholism, mental illness and stress in 96 drivers causing fatal accidents. *Behavioral Science*, 1969, *14*(1), 1-10.

Selzer, M. L., & Payne, C. E. Automobile accidents, suicide, and unconscious motivation. *American Journal of Psychiatry*, 1962, *119*, 237-240.

Selzer, M. L., Payne, C. E., Gifford, J. D., & Kelly, W. L. Personality versus intoxication as a critical factor in accidents caused by alcoholic drivers. *American Journal of Psychiatry*, 1963, *20*, 326-331.

Selzer, M., Rodgers, J., & Kern, S. Fatal accidents: the role of psychopathology, social stress, and acute disturbance. *American Journal of Psychiatry*, 1968, *124*(8), 1028-1036.

Selzer, M. L., & Vinokur, A. Life events, subjective stress, and traffic accidents. *American Journal of Psychiatry*, 1974, *131*(8), 903-906.

Shaw, L., & Sichel, H. S. The reduction of accidents in a transport company by the determination of the accident liability of individual drivers. *Traffic Safety Research Review*, 1961, 2-13.

Siegal, M. S. Driver training transportation and vocational adjustment of the handicapped in an urban setting. Symposium presented at the American Psychological Association, Washington, D.C., September 1969.

Siegrist, H. Evaluation of the fitness of the physically handicapped for driving. *Praxis*, 1971, *60*(17), 537-538.

Signori, E. I., & Bowman, R. G. On the study of personality factors in research on driving behavior. *Perceptual and Motor Skills*, 1974, *38*(3), 1067-1076.

Sipajlo, J. Techniques and experiences in teaching the handicapped to drive. Symposium presented at the American Psychological Association, Washington, D.C., September 1969.

Sipajlo, J. Course outline for advanced driver education for the physically handicapped. New York University, Center for Safety, 1973.

Slater, S. B., Vukmanovic, C., Mucukanovic, P., Pruvulovic, T., & Cutler, J. L. The definition and measurement of disability. *Social Science and Medicine*, 1974, *8*, 305-308.

Sluga, W. Psychiatric studies on driving ability (examination for driver licenses). *Wiener Medizinische Wochenschrift*, 1968, *118*(51), 1103-1107.

Smart, R. G., & Schmidt, W. S. Psychosomatic disorders and traffic accidents. *Journal of Psychosomatic Research*, 1962, *6*, 191-197.

Smith, H. B. Smith hand function evaluation. *American Journal of Occupational Therapy*, 1973, *27*(5), 244-251.

Somerville, W. The driver and his health. *Medicine, Science and the Law*, 1962, *3*, 423-427.

Sowton, E. Driving licenses for patients with cardiac pacemakers. *British Heart Journal*, 1972, *34*(10), 977-980.

Sparks, R. The medically unfit driver and the establishment of basic physical standards for licensure. *Journal of the Louisiana State Medical Society*, 1967, *119*(9), 348-351.

Personal Communication with J. Steensma, Jackson Memorial Hospital Rehabilitation Center, Miami, Florida, August 15, 1975.

Stiska, W. C. In car instruction for the mentally handicapped student. *Journal of Traffic Safety Education*, 1972, 19-20.

Stock, M. S., Light, W. O., Douglass, J. M., & Burg, F. D. Licensing the driver with musculoskeletal difficulty. *Journal of Bone and Joint Surgery*, 1970, *52*(2), 343-346.

Suhr, V. W. Personality and driving efficiency. Perceptual and Motor Skills, 1961, 12, 34.

Sullivan, R., Celikyol, F., & Commarote, L. Pre-driving evaluation for the brain damaged patient. Kessler Institute for Rehabilitation, West Orange, N.J.

Sussman, M. B. (Ed.) Sociology and rehabilitation. Report on the Conference on Sociological Theory, Research and Rehabilitation, Carmel, California, 1965. Washington, D.C.: American Sociological Association.

Tarnopol, L. Testing the educationally handicapped child. Academic Therapy Quarterly, 1967-1968, 3(2), 81-95.

Tabachnick, N., Litman, R. E., Osman, M., Jones, W. L., Cohn, J., Kasper, A., & Moffat, J. Comparative psychiatric study of accidental and suicidal death. Archives of General Psychiatry, 1966, 14, 60-68.

Three-wheeler conversion helps the disabled. Engineering, 1969, 208(5392), 207.

Trapnell, J. M., & Groff, H. D. Myocardial infarction in commercial drivers. Journal of Occupational Medicine, 1963, 5, 182.

U.S. Bureau of the Census. Census of population: 1976, subject reports final report PC(2)-6C, persons with work disability. Washington, D.C.: U.S. Government Printing Office, 1973.

U.S. Department of Commerce, Social and Economic Statistics Administration, Bureau of the Census. Persons with work disability. Subject Report, January 1973.

U.S. Department of Health, Education and Welfare, Bureau of Education for the Handicapped. Unpublished HEW statistics for the handicapped: Based upon unpublished medical reports.

U.S. Department of Health, Education and Welfare, Education Division, National Center for Education Statistics. The condition of education: A statistical report on the condition of American education, 1975. Washington, D.C.: U.S. Government Printing Office, 1975. Stock No. 017-080-01391-6.

U.S. Department of Health, Education and Welfare, National Center for Health Statistics, Health Interview Survey. Provisional prevalence of selected impairments and chronic conditions reported in health interviews, by age: United States civilian non-institutionalized population, 1971. Unpublished.

U.S. Department of Health, Education and Welfare, Office of Human Development, Rehabilitation Services Administration. Statistical reporting system, coding of disabling conditions. Rehabilitation Services Manual, July 1974.

U.S. Department of Health, Education and Welfare, Public Health Service. *Eighth revision, international classification of diseases, adapted for use in the United States: Volume I, Tabular list.* Washington, D.C.: U.S. Government Printing Office, Public Health Service Publication No. 1693, 1967.

U.S. Department of Health, Education and Welfare, Public Health Service. *Driver licensing guidelines for medical advisory boards: Relating functional ability to class of vehicle.* Washington, D.C.: U.S. Government Printing Office, 1969.

U.S. Department of Health, Education and Welfare, Public Health Service, Health Resources Administration. *Impairments due to injury: United States-1971.* Washington, D.C.: U.S. Government Printing Office, 1973.

U.S. Department of Health, Education and Welfare, Public Health Resources Administration. *Prevalence of selected impairments: United States-July 1963-June 1965.* Washington, D.C.: Library of Congress, 1973. Card Catalog No. 68-62239.

U.S. Department of Health, Education and Welfare, Public Health Service, Health Resources Administration. *Acute conditions--incidence and associated disability: United States-July 1971-June 1972.* Washington, D.C.: U.S. Government Printing Office, 1974. Publication No. HE 20.6209:10/88.

U.S. Department of Health, Education and Welfare, Public Health Service, Health Resources Administration. *Current estimates from the health interview survey: United States-1973.* Washington, D.C.: U.S. Government Printing Office, 1974.

U.S. Department of Health, Education and Welfare, Public Health Service, Health Resources Administration. *Limitation of activity and mobility due to chronic conditions: United States-1972.* Washington, D.C.: U.S. Government Printing Office, 1974. Publication No. HE 20.6209:10/96.

U.S. Department of Health, Education and Welfare, Public Health Service, Health Resources Administration. *Prevalence of chronic skin and musculoskeletal conditions: United States-1969.* Washington, D.C.: U.S. Government Printing Office, 1974. Publication No. HE 20.6209:10/92.

U.S. Department of Health, Education and Welfare, Public Health Service, Health Resources Administration. *Prevalence of selected impairments: United States-1971. Washington, D.C.: U.S. Government Printing Office,* 1975. Publication No. HE 20.2210:10/99.

U.S. Department of Transportation. *Transportation of the handicapped*. Bibliographic List *No. 1, November 1969, U.S. Department* of Transportation.

U.S. Department of Transportation. *Instructions for examining physicians to determine physical fitness of drivers engaged in interstate or foreign commerce.* Washington, D.C.: *U.S. Government Printing Office,* 1971.

U.S. Department of Transportation. *Analysis of the amputee-driver waiver program*. Washington, D.C.: U.S. Government *Printing Office, 1974*.

U.S. Department of Transportation. *Transportation for the handicapped--Selected references*. Bibliographic List *No. 8, April 1975,* U.S. Department of Transportation.

U.S. Department of Transportation, Federal Highway Administration. *Driver license administration requirements and fees*. Washington, D.C.: *U.S. Government Printing Office, 1968*.

U.S. Department of Transportation, Transportation Systems Center. The handicapped and elderly market for urban mass transit. Final Report, October 1973, Contract No. MA-06-0034, Urban Mass Transportation Administration.

Personal Communication with R. Urie, St. Andrews Presbyterian College, Laurenberg, North Carolina, August 15, 1975.

Voight, J. Road traffic death from natural causes. Proceedings of the Third Triennial Congress on Medical and Related Aspects of Motor Vehicle Accidents, 1969.

Veterans Administration. Automobiles and adaptive equipment for certain disabled veterans and members of the armed forces: standard design and test criteria for safety and quality. *Federal Register*, 1975, *40*(65), 15017-15020.

Wagner, E. E., & Schaff, J. E. Design reproduction with motor performance held constant. *Journal of Projective Techniques and Personality Assessment*, *1968, 32*(4), 395-396.

Waller, J. A. Chronic medical conditions and traffic safety: Review of the California experience. *New England Journal of Medicine*, 1965, *273*(26), 1413-1420.

Waller, J. A. Traffic accidents--chronic medical conditions as a cause. California Medicine, 1966, 105, 197-200.

Waller, J. A. Guide for the identification, evaluation, and regulation of persons with medical handicaps to driving. Washington, D.C.: American Association of Motor Vehicle Administrators, 1967.

Waller, J. A. Medical impairment and highway crashes. Journal of the American Medical Association, 1969, 208(12), 2293-2296.

Waller, J. A. Medical conditions--what role in crashes? New England Journal of Medicine, 1970, 283(8), 429-430.

Waller, J. A. Truth, traps, and tactics concerning alcohol, other drugs and highway safety. California Medicine, 116(2), 10-15.

Waller, J. A. Medical impairment to driving. Springfield, Ill.: Charles C Thomas, 1973.

Personal Communication with J. A. Waller. Problems of functional versus diagnostic classification, September 1975.

Waller, J. A., & Thunen, R. V. Medical handicaps to driving, the physicians dilemma in evaluation. California Medical Journal, 1963, 98, 275.

Wallner, T. Mental retardation and the mentally retarded as driving license applicants. Lakartidningen, 1974, 71(34), 3041-3402.

Ward, H. L., & Gingras, G. Medical aspects of traffic accidents in paraplegics. Canadian Services Medical Journal, 1956, 12, 459-463.

Warner, H. D. Methodological issues in traffic safety research. In Heimstra, N. W. (Ed.) Injury control and traffic safety. Springfield, Ill.: Charles C Thomas, 1970.

Washington, D.C., Department of Motor Vehicles. Diabetic drivers rated. 1973, Grant No. 691-1-003, Washington, D.C., Department of Motor Vehicles, U.S. Department of Transportation.

Washington, D.C., Department of Motor Vehicles. A mathematical-statistical analysis of the driving capability of medically impaired drivers. Interim Report, June 1973.

Weatherall, M. Drugs and the motorist. Medico-Legal Journal, 1959, 27, 44-56.

Weinstock, & Hoft, J. I. The effect of illness on employment opportunities. *Archives of Environmental Health*, 1974, *29*, 79-83.

Wenckstern, D. von. Traffic hazards due to drugs. *Zeitschrift fur Aerztliche Fortbildung*, 1964, *58*, 517-521.

West, I. The impaired driver, critical review of facts. *California Medical Journal*, 1963, *98*, 271-274.

West, I., Nielsen, G. L., Gilmore, A. E., & Ryan, J. R. Natural death at the wheel. *Journal of the American Medical Association*, 1968, *205*, 266-271.

Wheatley, G. M. The health of the driver. *Transcripts of the National Safety Congress*, 1965, *24*, 52.

Wilbar, C. L. Medical aspects of traffic safety. *Archives of Environmental Health*, *6*, 693-694.

Wilbar, C. Health aspects of the driver licensure program of Pennsylvania. *American Journal of Public Health*, 1965, *55*(11), 1807-1812.

Wisconsin State Medical Society. Medical evaluation of driver impairment. *Wisconsin Medical Journal*, 1967, *66*, 7-8.

Woodward, F. Seven medical proposals for the prevention of injury and death on the highways. *Southern Medical Journal*, 1966, *59*(5), 557-563.

Words and Phrases. 1965, *20A*, 328-329.

World Health Organization. *Diagnosis code*. 1974.

Williams, G. J., & Little, B. Driver education for the educable mentally retarded. *New York State Education*, 1966, 12-31.

Yoss, R. E. The sleepy driver: a test to measure ability to maintain alertness. *Mayo Clinic Proceedings*, 1969, *44*, 769-783.

Yoss, R. E., & Daly, D. D. Narcolepsy and the automobile. *Trauma*, 1963, *5*(2), 11-20.

Ysander, L. The safety of drivers with chronic disease. *British Journal of Industrial Medicine*, 1966, *23*, 28.

Ysander, L. The safety of physically disabled drivers. *British Journal of Industrial Medicine*, 1966, *23*, 173.

Ysander, L. Diabetic motor vehicle drivers without driving license restrictions. Acta Chirurgica Scandinavica, 1970, Supplement 409.

Ysander, L. Sick and handicapped drivers: A study on the risks of sudden illness at the wheel and on the frequency of road accidents and traffic offenses in chronically sick, disabled, and elderly drivers. Acta Chirurgica Scandinavica, 1970, Supplement 409, 1.

Ysander, L. Traffic medicine: 6: Ill and handicapped automobile drivers. Lakartidningen, 1971, 68(16), 1891-1897.

Zell, J. K., Rockwell, T. H., & Mourant, R. R. Visual search in driving as a function of experience. Paper presented at the annual meeting of the Human Factors Society, Philadelphia, October 1969.

Zino, R. L. Selecting a car for the instruction of physically handicapped students. Journal of Traffic Safety Education, 1972.

APPENDIX A

FOUR GUIDES TO THE LICENSING OF DRIVERS WITH CARDIOVASCULAR AND CIRCULATORY DISEASES

Nova Scotia Medical Society, The Committee on Traffic Accidents. Nova Scotia guide for physicians in determining fitness to drive a motor vehicle. The Nova Scotia Medical Bulletin, May 1966, 3-12.

Rheumatic Heart Disease

Appraisal must be made of the extent of damage of the valves and to the derangements in rhythm, particularly if likely to alter suddenly, and to the efficiency of the myocardium.

Aortic Stenosis

When marked is prone to lead to angina, syncope and sudden death. Patients with severe aortic stenosis should be advised not to operate a motor vehicle. Patients with lesser degrees of aortic stenosis without symptoms should be advised not to operate a passenger transport vehicle but may operate a commercial or private motor vehicle.

Patients with aortic insufficiency and left ventricular failure and dyspnoea or paroxysmal nocturnal dyspnoea should be advised not to operate a motor vehicle. Patients with a lesser degree of aortic insufficiency without dyspnoea should be advised not to operate passenger transport vehicles but may operate a commercial or private motor vehicle.

Patients with myocardial insufficiency due to mitral stenosis or insufficiency should be advised not to operate a commercial or passenger transport vehicle but may continue to operate a private vehicle when the myocardial failure, if any, is well controlled.

Subacute bacterial endocarditis necessitates immediate treatment and abstinence from operating any motor vehicle.

Uncontrolled auricular tachycardia, flutter or fibrillation and a rapid ventricular rate, unless controlled, cause severe incapacity and should be regarded as contraindications to operating any motor vehicle. However, when these disorders of rhythm are well controlled, such patients may operate a private motor vehicle. Because of the workload and the stress on the heart and because of the danger of embolization, patients with auricular fibrillation should be advised not to operate a commercial or passenger transport vehicle.

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Hypertensive Cardiovascular Disease

Hypertension in itself is not disabling for safe operation of a motor vehicle, but the complications arising from hypertension--i.e., damage to brain, eyes, heart or kidneys--may well prove to be disabling. When complications of hypertension are limited to the optic fundi, the degree of impairment of driving ability should be evaluated solely on the basis of loss of vision. If there is evidence of cardiac damage resulting in congestive heart failure or angina pectoris, such patient should be advised not to operate any motor vehicle unless the congestive failure or angina is well controlled by therapy, then the patient may only operate a private motor vehicle. The level of the blood pressure must obviously be interpreted in the light of its constancy. The patient's sex and the patient's age, as well as the degree of complications, must be assessed, before any decision is made to restrict driving ability on blood pressure figures alone. Fixed hypertension without complications is not a contraindication to operating a private or commercial motor vehicle.

Arteriosclerotic Heart Disease

If sclerosis of the coronary arteries has resulted in angina pectoris and these attacks are mild, infrequent and controlled with therapy, such patients may still drive private motor vehicles and light commercial but not heavy commercial and passenger transport vehicles.

More severe angina, even if accompanied by varying degrees of heart block, ventricular premature contractions or arrhythmias, if well controlled by therapy, need not prevent the operation of private motor vehicles. These patients should not operate commercial or passenger transport vehicles.

Severe angina brought on with little effort should be considered a contraindication to the operation of a motor vehicle.

The patient with acute coronary thrombosis should be advised that he should not operate any transport vehicle for at least two months following the attack. Assessment thereafter would be dependant upon the presence or absence of congestive circulatory failure or severe angina pectoria.

Syphilitic Heart Disease

Patient with syphilitic aortitis having syncope, congestive heart failure, or angina pectoris, should be advised not to operate a motor vehicle, unless these symptoms are well controlled by therapy, in which case it is permissible that they should drive a private vehicle but not a commercial or passenger transport vehicle.

Metabolic Heart Disease

If signs of myocardial insufficiency are present such patients should be advised not to operate a commercial or passenger transport vehicle but may operate a private vehicle.

Congenital Heart Disease

Asymptomatic congenital heart lesions are not contra-indications to safe driving. Patients developing signs of myocardial insufficiency should be advised not to operate a commercial or passenger transport, but may operate a private vehicle as long as their signs remained controlled by therapy.

Cor Pulmonale

Patients with right sided heart failures secondary to diseases of the lungs should be advised not to operate a commercial or passenger vehicle. However, if the symptoms of right ventricular failure, are mild and well controlled by therapy such patients may operate a private motor vehicle.

Myocarditis

Evidence of active myocarditis is a contraindication to the operation of a motor vehicle.

Arterial Aneurysms and Arteriovenous Fistulas

Any patient with an arterial aneurysm, because of the danger of rupture, should be advised not to operate a motor vehicle. Arteriovenous fistulas resulting in severe heart failure constitute a contra-indication to the operation of any motor vehicle. Both conditions may be amenable to surgical treatment.

Diseases of the Pericardium

In the acute phases of the pericarditis, patients under therapy are unable to operate any motor vehicle. Viral pericarditis does not constitute a contraindication to the operation of a motor vehicle, once the acute phase has subsided. Patients with chronic constrictive pericarditis may operate a private motor vehicle if the condition is well controlled, but should be advised not to operate commercial or passenger transport vehicles.

Cerebral Vascular Disease

Patients with inadequate blood flow to the brain, having attacks of syncope or dizziness should be advised not to operate a motor vehicle. If there has been any cerebral vascular episode causing changes in personality, alertness, ability to make decisions, or if there has been actual loss of motor or sensory power or co-ordination, such patients should be advised not to operate a motor vehicle. However, if such changes in function are minimal, with little or no disability, it may be possible for these individuals to drive private motor vehicles.

Disease of the Veins

Patients with thrombophlebitis or previous thrombophlebitis resulting in edema of the extremities and impairment of use should be advised not to operate a commercial or passenger transport vehicle, and if sufficient disability exists they should be advised not to drive a private motor vehicle. Patients with active phlebothrombosis should be advised not to drive a motor vehicle because of danger of embolism.

Cardiac Enlargement

Enlargement of the heart should not in itself be considered a contraindication to the operation of a motor vehicle but such enlargement points to the presence of organic heart disease, which deserves appropriate evaluation.

Dimished Cardiac Reserve

Minor degrees of impairment of function of the myocardium should not be considered a contraindication to the operation of a private or light commercial motor vehicle, but may not operate a heavy commercial or passenger motor vehicle. If myocardial insufficiency is more marked, the patient should be cautioned against the operation of a light commercial motor vehicle as it is likely to prevent proper performance under emergency conditions. If congestive heart failure is well controlled, such patients may operate private motor vehicles only.

Arrhythmias and Conduction Disturbances

Auricular premature beats are of little consequence and do not preclude the operation of motor vehicles. Patients with paroxysmal auricular tachycardia, flutter or fibrillation with myocardial insufficiency should be advised not to operate commercial or passenger transport vehicles. If, however, such attacks are well controlled by therapy, than the patient may operate a light commercial or private motor vehicle only. Auricular fibrillation of the chronic nature provides the risk of embolization from the auricles. Such patients should therefore, not operate a commercial or passenger transport vehicle but may operate a private motor vehicle if well controlled by therapy. Ventricular arrhythmias other than occasional ventricular extra systoles are usually associated with heart disease. Such patients should be advised not to drive commercial or passenger transport vehicles but may drive private vehicles if well controlled by therapy. Auriculoventricular block in a minor degree is of no significance. The patient with prolonged degrees of arterioventricular block or complete arterioventricular block, if associated with syncope (Strokes-Adams syndrome) should be advised not to operate any motor vehicle. If these attacks have been well controlled by therapy for one year or longer such patients may operate a private motor vehicle.

Hypotension

Hypotension in itself is not a contraindication to the operation of a motor vehicle. If, however, it results in attacks of syncope, such patients may operate a private motor vehicle. If hypotension is present and is considered to be related to symptoms of dizziness and or syncopal attacks it should be assessed in the light of the seriousness of the underlying disease process.

Carotid Sinus Sensitivity

Individuals with carotid sinus sensitivity who experience attacks of syncope should be advised not to drive a motor vehicle. If after therapy the patient is cured this decision should be revised.

U. S. Department of Health, Education, and Welfare, Public Health Service. *Driver licensing guidelines for medical advisory boards relating functional ability to class of vehicle.* Public Health Service Publication No. 1396, 1969.

Heart Disease (Table 2)

Acute myocardial infarction is the most common medical cause of sudden death behind the wheel. Though it represents the severest kind of driving impairment, it accounts for only a small proportion of highway accidents. Lesser degrees of acute coronary insufficiency may cause transient alterations of consciousness and anginal pain that can be distressing enough to result in significant impairment of driving ability. The level of consciousness may be impaired by two separate and distinct mechanisms. The first of these is inadequate perfusion of the brain secondary to a mechanically impaired heart. The second is impaired ventilatory capacity of the lungs secondary to heart disease. This latter category, often called dyspnea, may be caused by primary lung disease, but this will be considered separately.

Table 2. ORGANIC HEART DISEASE AND ACCEPTABLE LEVEL OF FUNCTION FOR DRIVER LICENSURE

Group	I Passenger transport	II Cargo transport	III Private auto	IV Periodic reevaluation	V Limited license
A	(Individual consideration)		yes	yes	no
B	no	no	yes	yes	yes
C	no	no	(unsafe-no)	no	no
D	(Individual consideration, based on risk)				

[a] Time to be set by evaluation of advisory board.

Organic heart disease is divided into three groups. A fourth group deals with certain arrhythmias.

Group A--A driver is in Group A when:

(1) he has asymptomatic heart disease, and

(2) the single or double Master's Two Step Test does not produce symptoms, or alterations of the ECG, and

(3) prolonged exertion, emotional stress, hurrying, hill climbing, recreation, or daily activities do not produce pathological symptoms, and

(4) signs of congestive heart failure are not present.

Group B--A driver is in Group B when he has organic heart disease and one or more of the following:

(1) walking one to two level blocks, climbing one flight of stairs, or the performance of usual activities produces symptoms, or

(2) Master's Two Step Test produces symptoms and ECG changes indicative of anoxia, or

(3) emotional stress, hurrying, hill climging, recreation or similar activities produce pathologic symptoms, or

(4) signs of congestive failure, if present, are relieved by therapy.

Group C--A driver is in Group C when he has organic heart disease with symptoms at rest, and one or both of the following:

(1) The performance of any of the activities of daily living beyond the personal toilet or its equivalent produces increased discomfort, or

(2) signs of congestive failure, if present, are resistant to therapy.

Group D--This group includes individuals with cardiac arrhythmias. While some of these ailments, such as chronic asymtomatic atrial fribrillation, usually do not present notable impairments, others such as paroxysmal atrial flutter do present a high risk of catastrophe. Hence, consideration must be based on their risk factor, which can be arrived at only by evaluating each disease entity.

Cardiac Pacemakers

Individuals with implanted pacemakers to control heart rate should not drive cargo or passenger transport vehicles. They may reasonably be permitted to drive private automobiles, if given a medical review at 3-month intervals by a physician familiar with cardiac pacemakers.

Hypertension Vascular Disease (Table 3)

Hypertension, because of its effects on the brain and other organs of the body, is of importance with respect to driving ability. A repeatedly elevated diastolic pressure over 90 mm Hg. in an untreated individual is, for purposes of these guidelines, assumed to be diagnosis of hypertension. Transient headaches from this disease must be judged on an individual basis to determine their severity, frequency, and subsequent interference with the individual's driving ability.

Table 3. HYPERTENSIVE VASCULAR DISEASE AND ACCEPTABLE LEVEL OF FUNCTION FOR DRIVER LICENSURE

Group	I Passenger transport	II Cargo transport	III Private auto	IV Periodic reevaluation	V Limited license
A	yes	yes	yes	yes	no
B	no	no	yes	yes	no
C	no	no	(Individual consideration)	yes	(Individual consideration) (usually unsafe)
D	no	no	(Individual consideration)	no	no

Group A--Diastolic pressure repeatedly over 90 mm Hg. and none of the following:

(1) abnormalities of urinalysis or urinary function tests;

(2) history of hypertensive cerebrovascular damage;

(3) evidence of left ventricular hypertrophy, or

(4) hypertensive abnormalities of the optic fundus, except for minimal narrowing or sclerosis of arterioles. (Keith-Wagner Retinopathy, Stage I).

Group B--A repeatedly elevated diastolic pressure over 90 mm Hg. and any one of the following:

(1) proteinuria and abnormalities in the urinary sediment but no impairment of renal function;

(2) history of hypertensive cerebrovascular damage without residuals;

(3) evidence of left ventricular hypertrophy, or

(4) definite hypertensive changes in the retinal arterioles without hemorrhages. (Keith-Wagner Retinopathy, Stage II).

Group C--A repeatedly elevated diastolic pressure over 90 mm Hg. and any two of the following:

(1) diastolic pressure usually in excess of 120 mm Hg.;

(2) proteinuria and abnormalities in the urinary sediment, with evidence of impaired renal function;

(3) hypertensive cerebrovascular damage with permanent neurological residuals;

(4) left ventricular hypertrophy;

(5) retinopathy of arterioles, with hemorrhages and exudates. (Keith-Wagner Retinopathy, Stage III).

Group D--Repeatedly elevated diastolic pressure over 120 mm Hg. and any two of the following:

(1) diastolic pressure usually in the range of 140 mm Hg. or more;

(2) proteinuria and abnormalities of the urinary sediment with evidence of nitrogen retention;

(3) hypertensive cerebrovascular damage with permanent neurological impairment;

(4) left ventricular hypertrophy;

(5) retinopathy of arterioles with papilledema. (Keith-Wagner Retinopathy, Stage IV)

Vascular Disease Affecting the Extremities (Table 4)

The importance of this category to the ability to drive safely depends on the impairment of the functional use of the affected extremity or extremities. This category is divided into three groups. Presence of vascular disease is presumed to have been diagnosed by existing conventional methods. Loss of pulses or arterial calcification is not considered an impairment to driving.

Table 4. VASCULAR DISEASES AND ACCEPTABLE LEVEL OF FUNCTION FOR DRIVER LICENSURE

Group	I Passenger transport	II Cargo transport	III Private auto	IV Periodic reevaluation	V Limited license
A	yes	yes	yes	yes	no
B	no	no	yes	yes	no
C	no	no	(Individual consideration)	no	no

Group A--A driver is in Group A when he has vascular disease and;

(1) experiences neither intermittent claudication nor pain at rest, or

(2) experiences only transient edema.

Group B--A driver is in Group B when he has vascular disease with any one of the following:

(1) intermittent claudication occuring on walking more than 25 yards;

(2) vascular damage evidenced by healed amputation of any number of digits of one extremity or amputations at or above the wrist or ankle of one extremity with evidence of persistent vascular disease;

(3) healed or persistent superficial ulceration, and

(4) moderate to marked edema which is only partially controlled by elastic supports.

Group C--A driver is in Group C when he has vascular disease with one of the following:

(1) intermittent claudication on walking less than 25 yards, or severe and constant pain at rest;

(2) vascular damage evidenced by amputations of 3 or more digits of each of two extremities, with persistent vascular disease;

(3) persistent, widespread, or deep ulceration involving any number of extremities.

Vascular Aneurysms

Arterial and arterio-venous aneurysms must be considered separately since they may not produce symptoms that interfere with driving. Some of these aneurysms, however, do have a high risk of rupturing. Therefore, they represent a serious danger, as they may cause a catastrophe. Each case should be given individual consideration. The following recommendations are intended to be very general:

(1) Femoral and Popliteal Aneurysms

These disorders usually are associated with prodromal symptoms that warn the driver of impending difficulty. Hence, drivers are usually able to avoid dangerous situations if complications develop. Persons with such conditions should be advised that long periods of sitting are dangerous to the aneurysm. After such advice, however, they should be able to drive private automobiles safely. They should not be recommended for licenses to drive cargo or passenger transport vehicles.

(2) Aortic and Central Nervous System Aneurysms

These vascular disorders present a very high risk and drivers of all types of vehicles should be given a careful individual evaluation of past history. In general, such individuals usually should not be recommended for cargo and transport licenses.

Quebec Ministry of Transport. Medical guide to determine ability to drive a motor vehicle. Department of Transport, July 1973.

Diseases of the Cardio-Vascular System

1. General Remarks

Heart disease does not in itself or by definition preclude driving. However, its limitations, which are intrinsic, depend on the degree of functional impairment resulting from the cardiopathy and how effectively medical or surgical therapy establishes a satisfactory cardiac output and controls certain risk-entailing factors.

2. Heart Failure

Whatever its etiology, heart failure entails a substantial and often sudden decrease in the cardiac output, which renders cardiopaths unfit for driving motor vehicles. Such a restriction can be modified, however, if the cardiac insufficiency can be corrected by surgery or by effective, controlled cardiotonic treatment. The New York Heart Association Nomenclature, which suggests four classes of functional incapacity, can be used as a basis:

I. Asymptomatic patient
II. Symptomatic patient during prolonged exertion
III. Symptomatic patient during mild exertion
IV. Symptomatic patient at rest

Theoretically, those classified I or II can be fit to drive all types of motor vehicles except buses and vehicles weighing more than 6,000 pounds.

Those classified III can be fit to drive private vehicles with restrictions H, J, K and L.

Those in class IV are considered unfit to drive motor vehicles.

Since, by definition, heart diseases are progressive and the state of cardio-circulatory restitution of limited duration, periodic check-ups of the cardiopath must be made once a year for cardiopathic drivers of private vehicles and every six months for those licensed to drive public vehicles.

Reports of these examinations must be sent to the Medical Director of the Motor Vehicle Bureau once or twice a year, as required.

3. Congenital Cardiopathy

What is true of valvular cardiopathy also applies to congenital cardiopathy. Cyanosis can be measured only by the functional results of a thorough hemodynamic examination. This also holds true for congenital aortic stenosis and hypertrophic muscular stenosis of the left ventricle. The suggested functional classification should be used as a guide for the evaluation of these heart diseases (see "Heart Surgery" #12).

4. Acute or Progressive Cardiopathy

Cardiopathy in the acute or progressive stage absolutely precludes driving.

5. Cardiomegaly

Cardiomegaly, not a disease as such, is often a manifestation of primary (family, alcoholic, and so forth) or secondary (sarcoidosis, hemochromatosis, and so on) cardiomyopathy. Assessment of cardiomegaly depends on the etiological element involved, the impairment of the cardiac output and the potential danger of conduction and rhythm disorders. Generally speaking those afflicted with cardiomyopathy are only fit to drive private vehicles with a maximum curb weight of 6,000 pounds.

6. Acquired Valvular Cardiopathy

All recommendations concerning the fitness for driving of people afflicted with valvular cardiopathy must be based on the functional effects of the lesion and its progression. The New York Heart Association Nomenclature can be used as a guide to symptomatic aortic stenosis, which, because it can cause sudden loss of consciousness or syncope, precludes driving.

7. Arrhythmia

In general, isolated arrhythmia, which is not related to a cardiopathy, does not render people unfit for driving private or public motor vehicles. Supraventricular paroxysmal arrhythmia (supraventricular tachycardia, flutter and paroxysmal fibrillation) must not increase and must be kept under observation if a person is to be declared fit for driving a 6,000 pound private vehicle.

8. Conduction Interference

A stable first degree atrioventricular block, which is not related to progressive myopathy, does not preclude driving public or private vehicles.

Second degree atrioventricular blocks and congenital third degree blocks, when permanent, asymptomatic and related to a sound ventricular rate, need not preclude driving private vehicles. It must be remembered that such conditions entail the danger of fainting spells; consequently, these patients must be reexamined every year. Total atrioventricular blocks and Adams-Stokes disease preclude driving. Those who wear electronic pacemakers may be declared fit for driving private vehicles as long as the condition and the effectiveness of the pacemakers are checked at least every three months.

9. Coronary Disease

A person who has suffered from myocardial infarction must not drive for two months following the attack. No patient who has suffered from myocardial infarction can be considered fit for driving passenger buses or ambulances. If the patient does not have anginal attacks, if his heart rate is not abnormal and he does not suffer from cardiac insufficiency, he may be granted a chauffeur's permit for all other public or private vehicles whose curb weight does not exceed 6,000 pounds. He must submit a medical report every six months to the Medical Director of the Motor Vehicle Bureau. If he holds an operator's permit, however, he need do so only once a year.

Any patient in the early stages of anginal syndrome or a period of obvious aggravation must be considered unfit for driving.

Stabilized anginal syndrome does not preclude driving private vehicles.

10. Arterial Aneurysm

All aneurysms of the major arteries, particularly of the aorta, can cause sudden death and therefore preclude driving unless they are successfully corrected by surgery. Once this has been done, licenses can eventually be granted for private vehicles whose curb weight does not exceed 6,000 pounds.

11. Hypertension

Asymptomatic hypertension and hypertension which responds to medication do not necessarily preclude driving. During the initial phase of hypotensor treatment and until the symptoms have been stablized, patients should be advised not to drive.

People with pathologic blood pressure can usually only hold an operator's permit for private vehicles with a maximum curb weight of 6,000 pounds; they must submit a medical report to the Motor Vehicle Bureau every year.

12. Heart Surgery

(A) Surgery to correct congenital cardiac or vascular defects

When such congenital malformations are totally and permanently cured by surgery, those afflicted may be considered cured and issued chauffeur's permits.

(B) Surgery to correct valvular lesions

The two most common types under this classification are:

(1) Commissurotomy for mitral stenosis: unless there are progressive symptoms, patients who have undergone this operation can usually be issued chauffeur's permits.

(2) Valve replacement: People with replaced valve can drive as long as they do not suffer from heart failure, arrythmia, fainting spells or angina pectoris.

(C) Coronary surgery

Whether the surgical technical was Vineberg's operation or an aorticoronary shunt, the same criteria as for myocardial infarction apply.

13. Conclusion

For all diseases under the heading "heart diseases," except where stated otherwise, chauffeurs' permits can be issued as well as operators' permits, but they usually bear restriction "H", that is, the curb weight of the vehicle must not exceed 6,000 pounds.

Diseases of the Cerebrovascular System

1. Cerebral Ischemia or arteriosclerosis

It is not safe for people to drive if they are subject to dizziness or syncopes as a result of intermittent vascular ischemia of the brain or cerebral arteriosclerosis.

2. Cerebral Hemorrhage or Infarction

It is not safe for people to drive if they have had a cerebral hemorrhage or infarction with a behavioral disturbance. If it is a minor disturbance, they can, however, drive private vehicles with a maximum curb weight of 6,000 pounds.

If the cerebral damage has resulted in impaired motor activity or coordination, the Motor Vehicle Bureau examiner must report to the Medical Advisory Committee on the person's behavior on the road. The Committee will then make its decision in light of the medical report and that of the examiner.

Canadian Medical Association, Committee on Emergency Services.
Guide for physicians in determining fitness to drive a motor vehicle.
Ottawa: Canadian Medical Association, 1974

4. CARDIOVASCULAR DISEASES

4.0 The Role of Cardiovascular Diseases in Driving

There is a lack of conclusive statistical data about the importance of cardiovascular conditions as a causative factor in motor vehicle accidents. However, it is felt that a physician can usually give a valid medical opinion as to the probability of sudden death, loss of consciousness, pain or weakness sufficient to cause loss of control of a vehicle. As with other disabilities, the drivers of passenger carrying and commercial transport vehicles are expected to meet higher standards of fitness because of the extra demands put on them.

4.1 Acute Cardiac Inflammation

Applicants with acute pericarditis or myocarditis should not drive any type of motor vehicle until they have made a full recovery. Applicants with sub-acute bacterial endocarditis are also unable to drive any type of motor vehicle safely until they are completely well because of the danger of embolism.

4.2 Congenital Heart Defects

Asymptomatic congenital heart lesions are by themselves no contraindication to the operation of any type of motor vehicle. Applicants with congestive heart failure or other symptoms arising from such defects should be assessed on the basis of the complications present. If the symptoms can be well controlled with treatment, an applicant can usually drive a private motor vehicle without difficulty but cannot usually drive a passenger transport or commercial vehicle (Class 1, 2, 3 or 4 license) safely because of the extra exertion often required.

4.3 Arteriosclerosis Heart Disease

(a) Angina Pectoris--Applicants with mild and infrequent attacks of angina pectoris that always respond well to therapy can usually drive a private motor vehicle safely but should not drive a passenger transport or commercial vehicle of any type because of the extra exertion frequently demanded in their operation. Angina, which occurs while the applicant is at rest and angina which is readily provoked by the effort required to maneuver a motor vehicle in a sudden emergency or by the annoyances of day-to-day driving, is absolute contraindication to any type of driving until reviewed by an appropriate specialist.

(b) Myocardial Insufficiency--If the oedema and dyspnea on exertion resulting from impairment of function of the myocardium is minimal the applicant can usually operate a private motor vehicle safely. If the dyspnea becomes so marked that it affects the performance of the usual duties involved in the operation of a motor vehicle or is likely to prevent proper performance in an emergency, the applicant should not drive any type of motor vehicle. If the congestive heart failure can be controlled by therapy, the applicant can usually resume driving a private motor vehicle, but should not operate a passenger transport or commercial vehicle (Class 1, 2, 3, or 4 license).

(c) Myocardial Infarction--Applicants who have had a myocardial infarction should not drive for at least eight weeks after clinical recovery as judged by their physician. It is felt that applicants who have had a proven myocardial infarction cannot thereafter operate a large passenger transport or heavy commercial vehicle (Class 1 and 2 license) safely because the possibility of a second infarction while on duty is significantly increased. Applicants who have had two proven infarctions should not thereafter operate a taxicab, ambulance, or smaller passenger bus (Class 4 license).

4.4 Cardiac Arrhythmias

(a) Premature Beats--Atrial or ventricular premature beats are of little consequence and in the absence of other abnormalities seldom preclude the safe operation of any type of motor vehicle.

(b) Paroxysmal Tachycardia--Paroxysmal auricular tachycardia is usually unimportant and only rarely limits physical ability. Paroxysmal tachycardia or ventricular origin, on the other hand, frequently signifies organic heart disease of a serious nature and persons with this condition cannot safely operate any type of motor vehicle until the underlying cause has been determined and corrected.

(c) Auricular Flutter and Fibrillation--Applicants with chronic auricular flutter or fibrillation can usually drive a private motor vehicle safely, provided their ventricular rate is well controlled by treatment and they do not have some other serious underlying cardiac condition. Since persons with chronic auricular flutter or fibrillation may develop emboli, it is felt unsafe for them to drive passenger transport or heavy commercial vehicles (Class 1, 2, 3, or 4 license).

(d) Bradycardia and Heart Block--Sino-auricular bradycardia and congenital auriculoventricular block, unless of marked degree, are usually of no significance. Applicants found to have auriculoventricular block should, however, be assessed on an individual basis. In younger persons, not acutely ill, even high grades of auriculoventricular block may be compatible with full activity. In older persons, heart block is more serious even in slight grades. If symptoms are well controlled by treatment older applicants with even a relatively marked degree of block can usually operate a private motor vehicle safely, but should never operate a passenger transport or commercial vehicle (Class 1, 2, 3, or 4 license).

4.5 Carotid Sinus Sensitivity

Applicants who become faint or lose consciousness when they are subject to carotid sinus pressure cannot drive any type of motor vehicle safely. If their carotid sinus can be made less sensitive, such applicants can drive a private motor vehicle safely after a period of observation to assure that the condition has stabilized.

4.6 Hypertension

Hypertension other than uncontrollable malignant hypertension, is not by itself a contraindication to the operation of any type of motor vehicle but the complications that can arise from the condition, such as damage to the heart, eyes, kidneys and brain, may well prevent safe driving. Persistent hypertension above 170/110 is frequently accompanied by complications that may make driving dangerous and applicants with a blood pressure in this range must be examined very carefully. If the eyes are found to be affected, the degree of impairment of driving ability will depend on the loss of vision. If the hypertension has caused cardiac damage resulting in congestive failure or cerebral impairment, this should be the principal consideration in evaluating the ability of the applicant to drive safely.

Higher standards should be required of passenger transport and commercial vehicle drivers than of drivers of private passenger cars. If the blood pressure is found to be 180/100 or more in such applicants, their evaluation should include an electrocardiogram, chest X-ray, funduscopic examination and BUN, and they should be referred to an internist for an opinion if a marked deviation from the normal is found.

Applicants who are found to have hypertension and who are placed on drug therapy should not drive any motor vehicle until their response to treatment has been observed and any necessary adjustment to their medication has been made.

4.7 Hypotension

Hypotension is not a contraindication to the operation of a motor vehicle. If, however, it results in attacks of syncope, such patients cannot safely operate any type of motor vehicle. If it is possible to control the syncope fully by treatment, the applicant can then usually operate a private motor vehicle safely but should not drive a transport or heavy commercial vehicle (Class 1, 2, 3, or 4 license).

4.8 Aortic Valve Disease

Applicants with minimal aortic valve disease who are quite free of symptoms can operate any type of motor vehicle safely. More severe disease, especially aortic stenosis, may cause unexpected attacks of faintness, dizziness or even syncope. Applicants with such symptoms cannot operate any type of passenger transport or commercial vehicle safely (Class 1, 2, 3, or 4 license) and must be evaluated on an individual basis to determine whether they can safely operate a private vehicle. Applicants with symptoms, if licensed at all, should be followed up regularly to ensure their continued fitness to drive.

4.9 Cardiac Pacemakers

Applicants who have had a cardiac pacemaker implanted can usually drive a private motor vehicle safely when this apparatus has successfully relieved them of their symptoms for a period of at least one month, provided they are regularly attending a pacemaker clinic or are being seen by their own physician at least once every three months. Such applicants cannot, however, drive a passenger transport or commercial vehicle (Class 1, 2, 3 or 4 license) safely because pacemakers, while they are becoming increasingly reliable, are still subject to unpredictable failures.

4.10 Prosthetic Valves

Applicants who have had a prosthetic valve(s) inserted are subject to emboli and to a lesser extent to failure of the valve mechanism. Such applicants can usually operate a private motor vehicle safely provided their prosthesis has successfully controlled their underlying cardiac condition. They should not, however, drive passenger transport or heavy commercial vehicles (Class 1, 2, 3, or 4 license).

4.11 Anticoagulants

The use of these drugs is not per se a contraindication to driving. The patient must be assessed with the underlying process in mind.

4.12 Coronary Bypass

Although the future may dictate that these patients are capable of handling all types of motor vehicles, at the present it is suggested they they should not operate a commercial vehicle (Class 1, 2, 3 or 4 license). Their ability to operate a private vehicle must be assessed very carefully (Class 5 only).